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Innovative Solutions to Human– Wildlife Conflicts

National Wildlife Research Center Accomplishments 2004



United States Department of Agriculture

Animal and Plant Health Inspection Service
Wildlife Services

National Wildlife Research Center

4101 LaPorte Ave.
Fort Collins, CO 80521-2154
<http://www.aphis.usda.gov/ws/nwrc>

Main Telephone Number:

(970) 266-6000
FAX: (970) 266-6032

Information Services:

(970) 266-6017
FAX: (970) 266-6010
email: nwrc@usda.gov

Animal Care:

(970) 266-6204

Research Programs:

Birds: (970) 266-6133
Mammals: (970) 266-6084
Product
Development: (970) 266-6159
Wildlife Disease: (970) 266-6262

NWRC Field Stations:

Bismarck, ND (701) 250-4468 FAX: (701) 250-4408	Olympia, WA (360) 956-3793 FAX: (360) 534-9755
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Gainesville, FL (352) 375-2229 FAX: (352) 377-5559	Sandusky, OH (419) 625-0242 FAX: (419) 625-8465
--	---

Hilo, HI (808) 961-4482 FAX: (808) 961-4776	Starkville, MS (662) 325-8215 FAX: (662) 325-8704
---	---

Logan, UT (435) 797-1348 FAX: (435) 797-0288	Philadelphia, PA (215) 898-3092 FAX: (215) 898-2084
--	---

Millville, UT, Office (435) 245-6091 FAX: (435) 245-3156	Kingsville, TX (361) 593-2426 FAX: (361) 593-3924
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INTRODUCTION

National Wildlife Research Center— Mission and Location

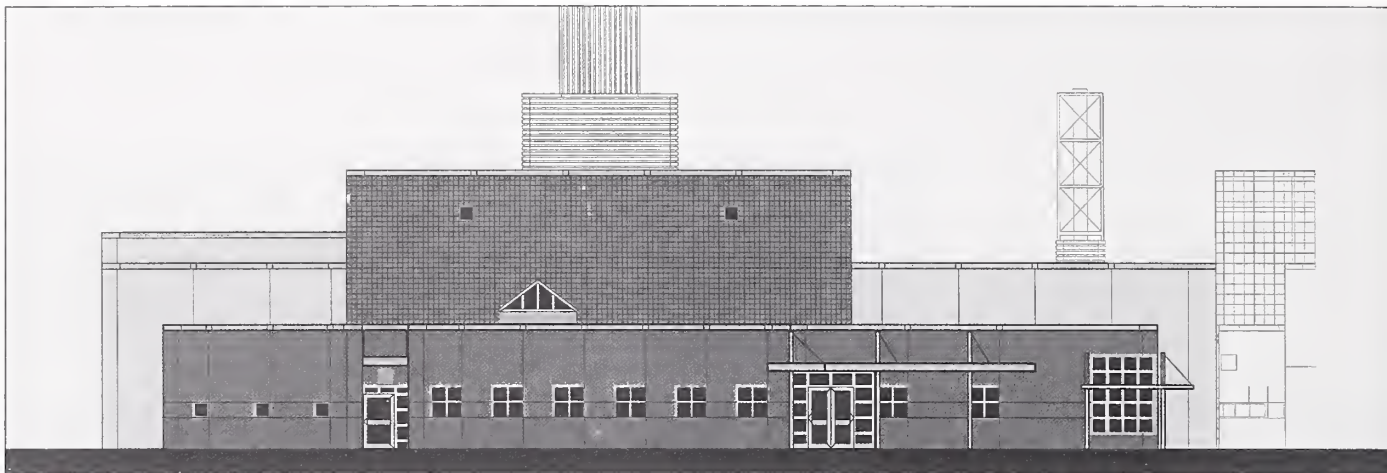
The mission of the U.S. Department of Agriculture's (USDA) Wildlife Services (WS) Program is to provide Federal leadership in managing problems caused by wildlife. The National Wildlife Research Center (NWRC) functions as the research arm of WS by providing scientific information on the development of socially acceptable methods for wildlife damage management. As part of WS' strategic plan to improve the coexistence of people and wildlife, NWRC has identified four strategic program goals: (1) developing methods, (2) providing wildlife services, (3) valuing and investing in people, and (4) enhancing information and communication. WS is dedicated to helping meet the wildlife damage management needs of the United States by building on NWRC's strengths in these four key areas. This annual research highlights report is structured around these program goals.

The headquarters of the NWRC is located on 43 acres on the Foothills Research Campus of Colorado State University (CSU) in Fort Collins, CO. During fiscal year (FY) 2004, the following planning and construction activities took place, related to completing the Master Plan for the NWRC site.



Construction Update—A support wing was added to the existing Animal Research Building (ARB) in 2004 to provide office space for the NWRC Animal Care Staff. In addition, two research laboratories and nine office cubicles have been provided for scientific staff. The new ARB support wing contains food-storage, food-preparation, and food-staging areas that service the Outdoor Animal Research Facility at

the NWRC site. A portion of the ARB was also renovated to create Biosafety Level 3 (BSL-3) laboratory space and animal holding/testing space for ongoing wildlife disease research being conducted at NWRC. The renovation created three small BSL-3 laboratory rooms plus two standard animal rooms and six animal cubicles that can be used for BSL-3 disease research.



The Phase Two bidding process for construction of the Invasive Species Research Building (ISRB) is now in process. The winning development team will receive the award to finish the ISRB design and construct the building. Anticipated completion is spring or summer of 2006.

The ISRB will provide NWRC with indoor animal research space specifically designed to maintain wild animal species that are invasive

to the United States. The building will be capable of maintaining tropical climates with high humidity and high temperatures.

The ISRB project is a lease/construct partnership project between NWRC and the General Services Administration (GSA). The developer will lease the building to GSA, and GSA will, in turn, have NWRC occupy the building as the Government tenant.

A partnership agreement between GSA and NWRC that was completed during FY 2004 began the planning for an eventual Wildlife Disease Research Building (WDRB) to be constructed at the NWRC site. The WDRB—a BSL-3 building throughout—will house most of NWRC's disease research. An environmental assessment for the WDRB has begun. It is the last major structure from the original 1990 master plan for the NWRC site remaining to be constructed.

Director Richard Curnow Retires—After nearly 37 years of Federal service, Dr. Richard D. Curnow, NWRC Director, announced his retirement effective April 3, 2004. Dick served as Assistant Director of NWRC from 1977 until 1994, at which time he became the Director. In that role, he spearheaded the planning, construction, establishment, and relocation of the Center from Denver to Fort Collins.

Over the years, Dick received numerous awards and recognitions, including the Federal Energy Saver Showcase Award, the USDA Secretary of Agriculture Honor Award, and the USDA Special Act Award. Dick was also recognized by the CSU Alumni Association in 2002 as a distinguished alumnus of the College of Natural Resources.

In retirement, Dick plans to enjoy his new house on the banks of the Poudre River near Fort Collins, fish and hunt at every opportunity, and spend time with his family, including



his two grandsons. We will greatly miss Dick's friendly personality and dedicated and professional leadership.

Richard Bruggers Named New Director—Dr. Richard L. Bruggers has been named as the new Director of NWRC. Rick started his career as a biologist in Africa with the United Nations before joining NWRC's International Program Section in 1979, first as a research biologist and later as the chief of the section. In his international career, Rick conducted research and provided technical assistance and program building in 36 developing countries. He has been with NWRC for more than 25 years in a number of positions of increasing responsibility and, for the last 10 years, served as the Assistant Director at the Center. He received his bachelor's degree in biology from Hope College in Michigan and his master's and Ph.D. degrees in biology from Ohio's Bowling Green State University.

**HOPPER LID MUST
BE CLOSED AND
LOCKED FOR
TAKE OFF
AND LANDING**

UNIT 1



DEVELOPING METHODS

Goal: Increase effective methods available for wildlife damage management.

BIRD RESEARCH PROGRAM

Project Title: Economic Impact and Management of Bird Predation at Aquaculture Facilities in the Southeastern United States

Goal: Determine the magnitude of and develop methodology to reduce damage by cormorants, wading birds, and pelicans on southern catfish, baitfish, and crawfish farms.

Fish-eating birds can have a substantial economic impact on aquacultural production. Annual costs associated with bird damage and damage prevention for aquaculture industries are estimated to exceed \$17 million. Double-crested cormorants, American white pelicans, and several wading birds are the predominant species associated with these conflicts. In addition to conflicts with aquaculture, double-crested cormorants have also been associated with habitat changes throughout North America. Present NWRC aquaculture research is aimed at acquiring information regarding the abundance, foraging behavior, economic impacts, and damage-management techniques associated with fish-eating birds near southeastern aquaculture facilities. Because these birds annually migrate from northern breeding areas to southeastern wintering grounds, the Center's research efforts should provide the information necessary to develop and evaluate management alternatives for fish-eating birds throughout their range.



The Potential for Fish-Eating Birds To Serve as Hosts of Catfish Parasites—

Catfish aquaculture is an important industry in the Southeastern United States. As with other types of agriculture, environmental factors, disease, and wildlife can impose economic hardships on individual producers and the industry as a whole. Two of the primary causes of economic loss in commercial channel catfish production are losses to diseases and parasites and losses to fish-eating birds. NWRC biologists collaborated in 2004 with the Mississippi State University College of Veterinary Medicine to characterize the life stages of an important catfish parasite, the *Bolbophorus* trematode.

A graduate student working with the College of Veterinary Medicine and a biologist at the NWRC Mississippi field station infected American white pelicans with *Bolbophorus metacercariae* from infected catfish. After subsequent trematode infections were established, trematode eggs were collected from pelican feces and used to infect snails, an intermediate host of the trematode. Free-swimming larval forms (Cercariae) shed from these infected snails were used to infect parasite-free catfish. Larvae in the infective stage (metacercariae) from these infected catfish were then fed to trematode-negative pelicans and allowed to mature to the adult stage. Parasitologists then isolated adult trematodes from the small intestine of the pelicans, completing the parasite's life cycle.

The results of this research provide important information on the parasite's life cycle, evidence that *Bolbophorus damnificus* is a separate species from similar trematodes, and further evidence that this parasite is the causative agent responsible for trematode-related catfish mortality in the Southeastern United States. A followup study initiated in 2004 validates the findings of earlier studies and indicates that, of the birds tested (great blue herons, double-crested cormorants, great



egrets, and American white pelicans), only American white pelicans served as a host of the *Bolbophorus* trematode.

Impacts of Cormorant Foraging Activities in Different Catfish Production Systems—Recent changes in the aquaculture industry have resulted in changes in production systems and dominance of multiple-batch

farming. This type of aquaculture involves growth of multiple size-classes of fish simultaneously in the same pond and periodic harvest of market-ready fish. NWRC scientists have initiated research to address these production changes and characterize the impacts of foraging by captive double-crested cormorants on channel catfish in multiple-batch cropping systems. These data will be combined with results of a study to determine the distribution and abundance of double-crested cormorants on catfish aquaculture in the Mississippi alluvial valley. NWRC scientists will integrate the results of these studies of cormorant habitat-use patterns with detailed studies of foraging impacts to investigate the potential for economic impacts from cormorant depredations and suggest management strategies to alleviate the damage.

Evaluating Management Strategies for Reducing Cormorant Damage to Natural Resources—In fall 2003, WS was granted expanded authority through new migratory bird management regulations to manage double-crested cormorants that impact aquaculture and natural resources. To ensure that wildlife



managers understand the implications of various management strategies, NWRC biologists are working with the WS operational program to determine how cormorants alter their behavior under different management regimes.

Biologists from the NWRC Mississippi field station continued work initiated in 2003 in New York to evaluate cormorant response to numerous nonlethal dispersal techniques aimed at discouraging these birds from using Oneida

Lake before and after breeding, thereby reducing impacts to recreational fisheries.

NWRC biologists, WS Operations biologists, and Michigan Department of Natural Resources biologists initiated a similar study in the Les Cheneaux region of Michigan in 2004 in response to localized depletions of harvest-sized yellow perch. These biologists are collecting information on perch populations, cormorant habitat use, and cormorant reproductive parameters in specific bodies of

water where perch problems have persisted. Information on these parameters will be combined with new research results on cormorant diet patterns and cormorant behavioral response to specific management strategies, including egg-oiling, nest destruction, and limited control of adult cormorants. These studies will help determine the role of cormorants in perch depletion and whether cormorant management can effectively reverse the depletion trends.

Project Title: Develop New or Improved Uses of Vulture Effigies and Population Models To Reduce Vulture Damage to Property, To Control Predation on Livestock, and To Disperse Nuisance Roosts

Goal: Develop practical, effective uses of taxidermic and artificial effigies to manage predation, aviation safety, and property-damage problems caused by black and turkey vultures. Examine population genetics and modeling as means to evaluate vulture responses to lethal control.

Vulture populations are increasing nationwide, particularly in the Southeastern United States. As vulture numbers increase, so do conflicts with human activities. Black vultures, for example, damage vinyl, plastic, and other synthetic construction and insulation material. Additionally, black vultures prey on newly born livestock and, in association with turkey vultures, form roosts that not only are nuisances (e.g., they can cause electric power outages) but also contribute to human health and safety problems. Vultures often forage at landfills, which in turn are often located near airports. In their daily flights to and from landfills to feed, vultures constitute a major hazard to aircraft. Problems related to vulture management show no sign of diminishing, and the need for efficient, practical, and safe methods of managing vulture damage situations is acute.



Monitoring Black Vulture Use of

Livestock Operations—During February through April 2004, biologists at the NWRC Florida field station worked with WS personnel in Virginia to document black vultures' use of livestock operations in the vicinity of a large winter roost in Radford, VA. This effort involved trapping and tagging 200 black vultures and also fitting 20 of these birds with radio transmitters. Biologists then quantified vulture activity at four livestock operations before and after the large roost in Radford was dispersed using lasers and vulture effigies.

Postdispersal monitoring continued for 2 months, during which 125 of the 200 tagged birds were sighted again at least once, some as far as 40 km from the original location. The telemetry data and the visual observations of tagged birds indicated that vulture activity was not affected by the dispersal of the Radford roost. This was due in large part to the availability of nearby alternate vulture roost sites that were documented in this study.

Dispersal of Vultures From Towers Using Artificial Effigies—In 2004, biologists at the NWRC Florida field station successfully tested an artificial vulture effigy at

three tower sites in north-central Florida. Daily counts of vultures on the structures before effigy installation averaged 91 birds. After several days of documenting vulture numbers on the towers at sunrise, the biologists installed an artificial effigy obtained from an Internet Web site. The effigy was a 38-cm-tall decorative bird, made with feathers glued to a hard foam body, with a plastic raptor-like head and feet.

Daily counts averaged 15 vultures with the effigy in place, a reduction of 84 percent. Similar levels of success have been obtained previously in dispersing vultures from tree roosts in residential settings.

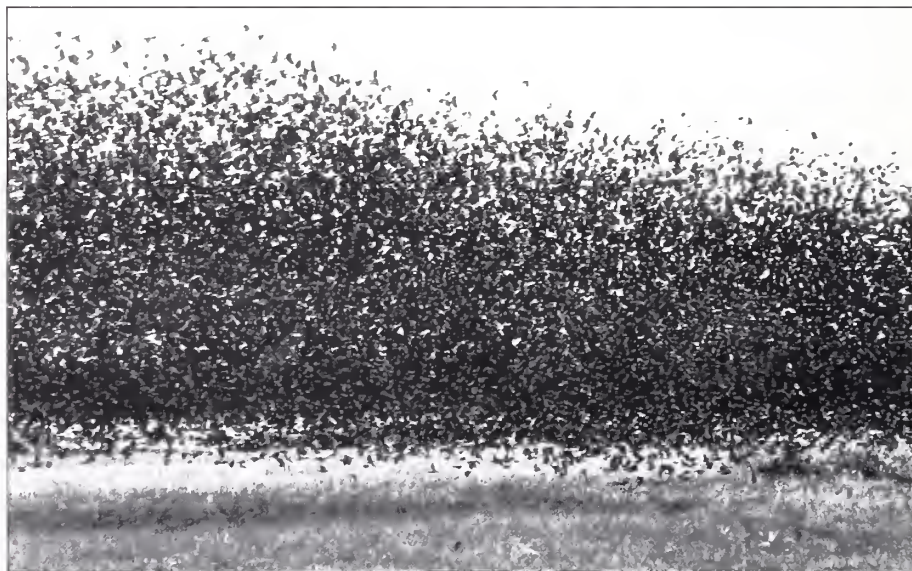
Project Title: Management of Bird Damage to Rice

Goal: Develop new or improved management strategies for reducing bird damage to rice.

Red-winged blackbirds, common grackles, and brown-headed cowbirds cause extensive damage to newly planted rice and ripening rice. NWRC researchers are focused on reducing bird damage to rice and improving profitability to growers by developing new or improved management strategies and expanding partnerships between rice producers, rice commodity groups, rice research boards, universities, and local, State, and Federal agencies.

Potential Blackbird Repellants for Rice

Evaluated—Scientists at NWRC in Fort Collins conducted a series of screening tests to evaluate GWN-4770, a registered fungicide product from Gowan Company, as a potential repellent for reducing blackbird damage to newly planted seed and ripening rice. In one-choice tests, rice consumption of 1 percent GWN-4770-treated rice by blackbirds was reduced more than 90 percent over the 4-day test period compared to a control group.



In no-choice tests, a reliable dose-response relationship was observed among treatment groups associated with the following concentrations of GWN-4770: 0.25, 0.5, 0.75, 1.1, and 2.2 percent. Compared to the pretest

period, rice consumption by blackbirds of 1.1-percent and 2.2-percent GWN-4770-treated rice was reduced 37 percent and 78 percent, respectively.

In addition, Aza-Direct™ and orange citrus terpene were evaluated under the same test design. Neither compound was effective in reducing blackbird consumption of treated rice.

A small-scale field test to evaluate the effectiveness of GWN-4770 and caffeine as blackbird repellants for rice was conducted near Gueydan, LA. Each compound was evaluated on 6 test sites that had intermediate blackbird activity, with about 100 to 200 blackbirds per site. Blackbird consumption of rice treated with 2-percent GWN-4470 and 1-percent caffeine was less than within control plots. Blackbird abundance was less on treated plots than on control plots among all sites associated with the caffeine treatment.

In addition, NWRC scientists cooperated with researchers from the Southeast Missouri State University to evaluate GWN-4770 as a seed treatment to reduce blackbird damage to drill-planted rice seed at the Missouri Rice Research farm near Malden, MO. Researchers planted 12 test plots, 6 of which were planted with 1-percent GWN-4470-treated rice and 6 with untreated rice.

At the conclusion of the test, there was no difference between the number of rice seedlings under wire enclosures and in uncovered assessment sites adjacent to the treated plots. Also, there was no difference between the number of rice seedlings under enclosures in the treated and control plots. However, blackbirds damaged more than 50 percent of the rice seedlings in assessment sites adjacent to enclosures in the control plots.

Although not effective for rice seed treatment, GWN-4770 and caffeine merit further testing as potential blackbird feeding deterrents for sprouted rice and ripening rice.

DRC-1339 Toxicity Tests—NWRC scientists have conducted more research on DRC-1339 than on any other avicide in the United States. This product has gone through the extensive testing required for registration with the Environmental Protection Agency (EPA) and has been used operationally in this country since 1967. Most acute oral toxicity testing of DRC-1339 in blackbirds has been conducted on small samples of red-winged blackbirds. No data previously existed on brown-headed cowbirds or great-tailed grackles. To strengthen the acute oral toxicity database on DRC-1339 used on blackbirds, NWRC scientists conducted toxicity tests that met EPA's current standards, which are based on 10 birds per each of 5 levels. Dose-response curves showing the range from LD₀ to LD₉₉ were developed for brown-headed cowbirds, red-winged blackbirds, and common grackles. The LD₅₀s for brown-headed cowbirds, red-winged blackbirds, and common grackles are 1.8, 2.5, and 0.7 mg/kg, and the LD₉₉s for the same species are 3.1, 3.6, and 3.7 mg/kg, respectively. The data from this study are a key component for developing a predictive model to estimate the take of blackbirds from DRC-1339 baiting operations.

Predictive Model Will Estimate the Mortality of Blackbirds From DRC-1339 Operational Baiting in Louisiana, Texas, and Missouri—Information is lacking for estimating the mortality of target blackbirds from DRC-1339 baiting operations. The number of rice grains actually consumed by blackbirds at DRC-1339 bait sites is not well documented but is a key factor in determining the consumption rate of birds using these sites.

From 2000 through 2004, NWRC scientists collected 2,781 blackbirds as they were leaving several bait sites in Louisiana, Texas, and Missouri. The esophagus and gizzard contents of each bird were analyzed to determine how many rice grains the bird had consumed. In all,

1,984 red-winged blackbirds, 658 brown-headed cowbirds, 138 grackles (common, boat-tailed and great-tailed), and 1 yellow-headed blackbird were collected.

On average, blackbirds visited bait sites for less than 5 minutes before departing to another foraging area. Some birds had eaten no rice at all. Red-winged blackbirds consumed up to 205 rice grains and averaged 31/bird. Brown-headed cowbirds consumed up to 204 rice grains and averaged 41/bird. Grackles consumed up to 265 rice grains and averaged 51/bird.

A model will be developed using a combination of parameters such as bait concentration, toxicity, bait consumption, bait dilution rate, and species composition to estimate blackbird mortality during DRC-1339 baiting operations.

Colorimetric Method Determines Presence of DRC-1339 in Blackbirds—

The current analytical method for determining the presence of DRC-1339 residues in birds, specifically blackbirds, can be time consuming, and the number of samples that can be processed at one time is small. In many cases, researchers only need to know if DRC-1339 is present or absent in a target bird. NWRC scientists developed a simple colorimetric method that can be used in the field to disclose the presence of DRC-1339 in gizzard contents of birds. The presence of DRC-1339 in a processed solution creates a reaction causing the solution to turn from clear to pink at a low DRC-1339 concentration and to bright red at higher DRC-1339 concentrations.

The method is 100-percent reliable for determining the presence of DRC-1339 in blackbirds collected within 30 minutes of consuming a DRC-1339-treated rice bait. A technician can analyze about 50 samples in an 8-hour period, whereas only about 7 samples can be analyzed under the current DRC-1339 residue method in that timeframe. The utility of

the colorimetric method allows researchers or operations personnel to validate the expected number of target and nontarget birds that consumed at least one treated rice grain from a DRC-1339 bait site.

Economic Impacts of Blackbirds on Rice

The Louisiana Rice Research Board and the Rice Foundation funded a study in 2003-04 to estimate the economic impacts of blackbirds on newly planted and ripening rice in Louisiana, Texas, Arkansas, California, and Missouri. Survey areas in rice-producing States were identified based on the National Agricultural Statistics Service's rice harvest records. NWRC scientists developed a questionnaire to survey rice operators to determine the extent of bird damage, bird species responsible for damage, economic loss, and

associated costs to reduce bird depredations. Questionnaires were sent to 5,833 rice operators. Of those, 969 returned the questionnaire, representing 178,343 ha of croplands.

Overall, 62 percent of the operators that farmed rice in 2001 reported damage from birds, specifically from blackbirds. Those operators reported blackbird damage to 23,526 ha of newly planted rice and 39,104 ha of ripening rice. The total production loss of 25,705,300 lb of rice at 2001 prices is valued at \$1,490,907. In addition, 56 percent of the rice operators reported bird damage in previous years starting with 1996.

Blackbirds were identified as the species causing the most damage to newly planted rice and ripening rice. For all States, about 67 percent of the operators reported that blackbirds

caused the most damage to ripening rice, ranging from 6 to 14 percent. Arkansas operators reported the highest damage to ripening rice. Blackbird damage to newly planted rice for all States ranged from 6 percent to 15 percent. Louisiana operators reported the highest damage to newly planted rice.

Rice operators (503) who responded to questions regarding bird control spent \$633,154 to prevent bird damage to their rice, or about \$1,259 per operator. Roughly 6 percent of the operators spent more than \$4,000 on hazing birds from their rice. Shooting and propane cannons were the most widely used methods for bird control. Of interest were the responses from rice operators to a question regarding WS. Of 744 rice operators from all States, only 231, or 31 percent, had heard of USDA-WS.

Project Title: Development and Evaluation of Management Techniques for Reducing Blackbird Damage to Ripening Sunflower Crops and Feedlots

Goal: Develop new and/or improved methods to reduce blackbird damage to ripening sunflower crops and feedlots.

Blackbirds and starlings are responsible for damaging grain crops and sunflowers and eating livestock feed. NWRC investigators are evaluating the efficacy and environmental impacts of using DRC-1339 to reduce blackbird and starling populations and nonlethal repellent techniques to reduce their damage to crops. Population models on blackbird distribution and abundance and a database on the basic ecology and regional movements of blackbirds in relation to sunflower and livestock feed damage are also being developed.



Wildlife Conservation Sunflower Plots as a Dual-Purpose Wildlife Management Strategy—

The National Sunflower Association has identified blackbird damage as a key reason for growers to abandon planting sunflowers. In the 1980s, NWRC scientists showed that “decoy” plantings of sunflower can significantly reduce bird damage to nearby commercial sunflower fields. For a variety of reasons, largely logistical and economic in nature, decoy sunflower fields did not become widespread. Over the last decade, new Federal farm programs have placed more emphasis on wildlife conservation. Thus, decoy sunflower fields planted to ameliorate blackbird damage and establish habitat for wildlife, especially migratory birds, might garner broad support from both agricultural and conservation groups.

To quantify avian use of sunflower fields, scientists randomly selected 12 oilseed variety sunflower fields and visited these fields 7 times from 22 August to 11 October, 2003. Scientists observed 49 nonblackbird species in or over the sunflower fields. Of those 49 species, 61 percent were granivores, including 16 species of sparrows and 3 species of finches. Granivores made up 74 percent of all birds counted in both the field and field edges. Of 2,159 birds recorded in sunflower, 66 percent were granivores, 21 percent were insectivores, and 10 percent were unidentified. The most common birds were song sparrows, grasshopper sparrows, clay-colored sparrows, dark-eyed juncos, and savannah sparrows. Thus, these preliminary data on avian use of ripening sunflower fields support the notion of Wildlife Conservation Sunflower Plots as a broad-based dual-purpose wildlife management strategy.



Influences of Land-Use Patterns on Blackbird Abundance in the Prairie Pothole Region of North Dakota—

Crop depredation by blackbirds in the upper Great Plains of North America is an issue affecting many sunflower growers. In this region, blackbirds annually destroy an average of \$5.4 million worth of sunflower crops.

To increase the understanding of how blackbird populations are influenced by large-scale land-use patterns, NWRC scientists developed multiple-regression models. Data from the North American Breeding Bird Survey and the U.S. Geological Survey's land-cover assessment were used to develop regression models examining associations between land-use characteristics and blackbird abundance. Both red-winged blackbirds and yellow-headed blackbirds were negatively associated with the amount of developed land, while the amount of wetland strongly influenced yellow-headed blackbird abundance. Common grackles were positively associated with the number of land-use types in the landscape.

These associations can be partially explained by habitat preferences of these species; however, many variables that would seem to be good predictors of blackbird abundance proved not significant. This result suggests that either a greater number of samples is needed to identify these associations or the relationships in question are not detectable at the landscape level.

Avian Use of Roadside Habitat in the Southern Drift Plains of North Dakota and Implications of Cattail Management—

NWRC scientists determined avian use of roadside rights-of-way to develop proper management strategies for the manipulation of roadside cattail. Cattail management is a technique used to reduce nesting and roosting habitat for problematic blackbird species, which might feed on sunflower crops in the vicinity of cattail-dominated wetlands.

Roadside habitat along 2 half-mile (≈ 0.8 -km) transects bordering 30 quarter sections (1 quarter section ≈ 64.75 ha) located in the Southern Drift Plains of North Dakota were surveyed to assess avian use. Additionally, nest surveys were conducted to provide an index of breeding-bird use of this roadside habitat. Finally, roadside habitat was surveyed for a number of different habitat variables.

Forty-nine different species of birds were found during the surveys. Of the 2,529 birds found in this habitat, 1,479 (41.5 percent) were blackbirds. Blackbirds were also the primary nesting birds, contributing to 89 percent of the active nests found in roadside habitat. In terms of avian use and nesting, blackbirds, especially redwings, were the dominant bird species using roadside cattail.

Proper management of roadside habitat can minimize potential effects on nonblackbirds while at the same time reducing the acreage of nesting habitat for blackbirds. These data indicate that a reduction in nesting habitat along roadsides could result in fewer blackbirds and a subsequent reduction in sunflower damage.

Project Title: Defining and Reducing Wildlife Hazards to Aviation

Goal: Provide a scientific foundation for WS programs at airports throughout the United States to reduce wildlife hazards to the aviation industry.

To be certified for passenger traffic by the Federal Aviation Administration (FAA), most U.S. airports are required to have wildlife hazard-management plans in place. In addition, the FAA has strict standards regarding the capabilities of aircraft engines to withstand bird strikes and the siting of wildlife attractants, such as waste-management facilities, near airports. An interagency agreement between NWRC and the FAA was established in 1991 to provide the FAA with scientific support for recommendations and policies to control wildlife hazards to the aviation industry. These wildlife hazards are primarily caused by federally protected bird species, although certain mammals (e.g., deer) can also be a problem. Research and information needs cover a broad spectrum of topics related to understanding the nature of wildlife hazards at airports, developing management tools that will reduce these hazards, and providing airport personnel with information on the latest strategies for controlling wildlife hazards.

Use of FLIR (Forward-Looking Infrared) To Census Wildlife—Traditional offroad transect surveys for moderate-size mammals sometimes suffer from observer disturbance of the target species, causing flight or even attraction to the observer. Either effect can bias the data necessary to accurately estimate animal population densities. In addition, both aerial surveys of white-tailed deer and night-



time sharpshooting of deer on airports to remove hazards to aviation rely on human perception of animals against natural backgrounds.

Recently, researchers at the NWRC's Ohio field station evaluated FLIR imaging against traditional night-time sighting methods (e.g., spotlights and night-vision technology) to survey white-tailed deer and found the FLIR technology to be superior. Infrared technology allows an observer to discern target animals against background vegetation, an improvement over traditional sighting methods. The researchers also introduced the FLIR technology into vehicle-based line-transect survey methodology to estimate raccoon population density. WS biologists now use FLIR in the airport environment for deer and small-mammal censuses and removal, and in wildlife disease-related efforts.

Evaluation of ElectroBraid™ Fencing as a White-Tailed Deer Barrier—White-tailed deer populations continue to increase, resulting in direct threats to public safety and greater agricultural losses. Various fencing methods are used to reduce deer presence at airports and agricultural areas. Electric fences might offer a less expensive alternative to expensive woven-wire fences. Scientists tested an electric fence product, ElectroBraid™, on free ranging deer during winter months in northern Ohio.

In all tests, deer intrusions into a feeding trough of corn were reduced from 57 to 99 percent, depending upon the experience of the deer with the fence. Those deer that penetrated the fence did not touch their nose or ears on the fence. The size of the enclosure, which ranged from 25 to 2,000 m², did not influence the rate of intrusions. Under the conditions of the test, the ElectroBraid product provided an effective and economical deer barrier.



WS Program Effectively Reduces Gull Strikes at John F. Kennedy International Airport (JFKIA)—

In 2003, WS successfully completed its 13th year of providing assistance to the Port Authority of New York and New Jersey at JFKIA. As part of an integrated wildlife damage-control program, biologists have removed more than 68,700 laughing gulls and more than 9,100 other gulls over the life of the project. This joint operational and research program has been very successful in reducing gull–aircraft collisions at JFKIA. Laughing gull–aircraft collisions have been reduced by 76 to 99 percent annually compared with the baseline years of 1988–90. Aircraft collisions with other gulls were reduced by 48 to 76 percent at the same time.

The nearby laughing-gull nesting colony located in Jamaica Bay, which increased from 15 to 7,629 nests from 1979 through 1990, has declined by 71 percent during the years that WS has been removing birds over the airport, to 2,195 nests in 2003. An annual shooting program at JFKIA, although effective in reducing the number of gull–aircraft collisions, has not eliminated the nearby nesting colony or caused a decline in the regional laughing-gull population.

Although this program has been extremely successful, JFKIA must continue improving its integrated management program to minimize strikes by gulls and other bird species. As part of this effort, NWRC scientists began a study in 2003 to understand the feeding habits and the temporal patterns in food selection of the gulls that should provide insight into their movement patterns. Laughing gulls leaving the nearby nesting colony on Jamaica Bay Wildlife Refuge often fly directly across JFKIA, presumably to feeding areas throughout metropolitan New York City or potentially on the airfield



itself. If laughing gulls are feeding on certain insect species on the airfield, it might be possible to remove those resources to deter gull foraging.

Stomach-content analysis was conducted on 470 laughing gulls collected during the 2003 gull strike-reduction program. Invertebrate resources in various habitats on JFKIA were sampled weekly from May to September of 2003. Preliminary findings from this study suggest laughing gulls associated with the Jamaica Bay nesting colony utilize a variety of forages. Foods of marine (e.g., horseshoe crab eggs), terrestrial (e.g., insects), and anthropogenic (e.g., french fries) origin comprised 62 percent, 22 percent, and 16 percent, respectively of laughing-gull diets.

Endophyte-Infected Tall Fescue May Provide a Tool for Airport Vegetation Management—Habitat management is the most effective long-term method of reducing



the attractiveness of airfields to wildlife that present hazards to aviation. Planting vegetation mixtures that are unattractive to wildlife should reduce the risk of damaging bird strikes. In 2003, NWRC scientists completed a study begun in 2000 to examine foraging preferences of Canada geese.

In 2000, replicate plots of two vegetation mixtures, one predominantly endophyte-infected tall fescue and the other predominantly perennial ryegrass, were planted in six replicate plots. Experimental observations of the behaviors of captive Canada geese in these plots, especially foraging, were conducted July–August 2001. Canada geese showed no preference between the two vegetation types when loafing or feeding during 2001.

The vegetation plots were allowed to establish themselves further during 2002–03, and the Canada goose foraging-preference tests were repeated July–August 2003. After 3 years, the tall-fescue plots were well established (mean of 91 percent tall-fescue cover) and provided an excellent opportunity to study the preference between the two vegetation mixtures by Canada geese.

During 2003, captive Canada geese fed almost exclusively in the perennial ryegrass mixture plots and avoided feeding in the tall-fescue plots. This study suggests that endophyte-infected tall fescue might be a favorable species for airfields and other areas where Canada geese are unwanted.

Project Title: Enhancing the Effectiveness of Nonlethal Avian (blackbird/starling) Repellants and Mammalian (skunk/raccoon) Attractants

Goal: To better understand the factors that modulate learning and memory in order to improve the effectiveness of currently available avian repellants and to develop chemical attractants specific to skunks and raccoons.

Despite considerable demand for nonlethal methods of wildlife damage management, few effective chemical repellants and selective attractants exist for most applications. Fundamental physiological data concerning olfaction, taste, and trigeminal chemoreceptive abilities of wildlife are largely nonexistent, and the application of existing behavioral data to enhance wildlife control technologies is lacking. This project investigates the chemosensory morphology, histology, and physiology of sensory system function in several wildlife species important to the WS program.

Testing of Natural Products To Repel Starlings—In a collaborative effort between a scientist at a New York university and the NWRC Philadelphia field station, testing was conducted on a new product comprised of woodchips infused with garlic oil. Laboratory studies indicated that the product repelled European starlings from food in one-choice tests. Additional research is necessary to determine whether the laboratory findings can be extended to new situations. Additional studies with different species of birds and in field settings will be undertaken in 2005.

Other research continues to examine the suitability of new materials, particularly secondary plant compounds, for use as avian repellants.



At the same time, new ways of applying these compounds are being explored. One new strategy is to encase plant compounds in dead yeast cells. This packaging may allow delivery of repellants into the gastrointestinal tract, which in some cases (such as with methyl anthranilate) would allow the repellant to function secondarily. Secondary repellants are those that cause malaise; these are known to be much more effective than primary repellants, which cause irritation, such as chili peppers for humans.

Repellants May Become Ineffective With Overuse

—A collaborative study between the NWRC Philadelphia field station and Monell Chemical Senses Laboratory produced data showing how repellants might become ineffective as a result of overuse. The results show that, as more habitat patches are treated with a repellant, its efficacy disappears completely. This situation has potentially important practical implications for the use of repellants in the field. Further research will test the effect of abundance on consumption of foods treated with secondary repellants.

Starlings Can Detect Conspecific

Odors—Earlier studies conducted by NWRC scientists revealed that the chemosensory systems of birds (taste and smell) are as sensitive as those of many mammals, such as rats and mice. More recently, research has found that starlings can detect odors from conspecific organisms (those belonging to the same species). The area of avian chemical communication research is new, and the significance of such research results has yet to be exploited. These results highlight the importance of an untapped sensory modality in birds that might be a target for future repellants or attractants. The next phase of the project will be to determine if birds detect predator odors such as cat urine, and if so, whether these odors are aversive to birds.

MAMMAL RESEARCH PROGRAM

Project Title: Developing Tools and Strategies To Reduce Mammalian Impacts on Forest Resources

Goal: Provide feasible nonlethal solutions and improved rodenticides for forest managers to resolve problems encountered with selected wild mammals.

Foraging wildlife affect forest resources in numerous ways. Damage can result in reduced productivity, delayed harvest cycles, failure to replace trees after a harvest or a fire, or failure to establish native plants. Managing resources to resolve these problems is becoming increasingly difficult because the land base to produce timber is shrinking, reducing management options while increasing the necessity to protect remaining resources. There is a critical need for enhanced research to develop new nonlethal approaches and improve existing approaches.

A Potential New Tool For Mountain Beaver Control

—Mountain beavers are fossorial rodents endemic to the Pacific Northwest and portions of California. This herbivore is managed as a pest species because of the impact it has on newly planted Douglas-fir seedlings. Attempts to manage mountain beaver through repellants, barriers, and trapping are costly and not always productive. In addition, trapping, the most reliable method to control mountain beaver populations is becoming less politically and socially acceptable. Therefore, alternative tools to traps to control mountain beaver populations are desirable. At present there are no toxicants registered for mountain beaver use; however, four toxicants are registered for underground control of other species. Several studies assessed the potential of these four toxicants



registered for underground use to control mountain beaver: zinc phosphide, strychnine, diphacinone, and chlorophacinone.

Zinc phosphide and strychnine are acute toxicants, whereas diphacinone and chlorophacinone are anticoagulants. Anticoagulants prevent the recycling of vitamin K in the body, which inhibits the production of clotting factors. Efficacy varied among treatments. Mountain beaver avoided zinc phosphide and strychnine baits. Prebaiting marginally

increased acceptance of strychnine but did not alter mountain beaver acceptance of zinc phosphide. Diphacinone and chlorophacinone were both readily consumed, but only chlorophacinone was 100-percent effective after a 14-day baiting regime.

Subsequently, the effects of diet were tested on the efficacy of diphacinone by varying the availability of food containing vitamin K, the anticoagulant antidote. Restricting access to potential sources of vitamin K appeared to

increase efficacy. These tests show that anticoagulants hold promise as additional tools for managers to reduce mountain beaver populations, with chlorophacinone showing the most promise. Based on the initial screening tests, subsequent studies were performed to further evaluate chlorophacinone as a potential tool for mountain beaver.

Daily baiting would be an unreasonable and costly alternative for timber managers, so a series of tests was done to determine if a single or double baiting was efficacious. In addition, tests evaluating the caching behavior of the mountain beaver when offered bags of oats were completed. This behavior may help reduce impacts to nontarget species as well as reduce environmental exposure and degradation of the baits. Mountain beaver readily cached bags of chlorophacinone within their artificial burrows, and one-time and two-time doses were 100 percent effective. The highest chlorophacinone residue in mountain beaver tissue was 0.354 p/m; based on these residues, the risk quotient for mink and red-tailed hawk was exactly at the level of concern that EPA recognizes for endangered and threatened species.

Currently, EPA is reviewing a request to test chlorophacinone in a field efficacy trial. If efficacy is shown through a field trial, NWRC scientists hope to develop chlorophacinone as a new tool for operational use for managing mountain beaver.

Seedling Damage and Reproductive Condition in Mountain Beaver—The mountain beaver is among a variety of herbivores that retard the growth of seedlings and cause seedling deformities and mortality. Douglas-fir seedlings are planted in the Pacific Northwest from February through March, a period coinciding with mountain beaver parturition. Previous research suggested that: (1) lactating females depend more on conifers in the spring than do nonlactating females and

males, (2) lactating females take in a diet with high water content, (3) Douglas-fir needles and not stems were ingested, (4) no Douglas-fir clippings were found in outside caches, and (5) a very low proportion of conifer was found inside four food chambers.

Managers have extrapolated from these data to conclude that female mountain beaver may cause more damage than males on newly planted units. Scientists at the NWRC Olympia field station conducted experiments to determine if female reproductive condition influenced seedling damage and if growth stage of the seedlings affected damage. Dormant and flushing trees were offered to six pregnant and six nonpregnant females in 2002 and 2003. No difference was found between female condition and damage in 2002, but there was a significant difference between tree type (dormant or flushing) and damage. In 2003, the researchers found a difference in seedling damage, with both tree type and female condition contributing to the model. More flushing trees were damaged in both years than dormant trees once budbreak occurred.

Statistical analyses of fructose and glucose concentration data indicate that tree type was a significant factor in amount of damage. The interaction between tree type and week sampled was also significant in both the glucose and fructose response. Both fructose and glucose concentrations were the lowest in new flushing trees, and mountain beaver did not appear to be selecting flushing trees for their needle sugar content.

Water concentration also varied between tree type but was not affected by the sampling time. New and dormant growth tissues had similar water concentrations, which were greater than old-growth tissue. Mountain beaver are dependent upon a constant water source, although it does not appear that damage is related to water availability.

One problem with trying to conduct this type of experiment is the uncertainty of whether females are able to successfully raise their litters. Once the animals were introduced into the habitat pens, we had no way to be sure litters would be raised to weaning. Mountain beaver tend to be easily stressed and will often kill their young under stressful situations. Even with minimizing the disturbance in the habitat pens, complications may still have arisen. Half of the females in 2002 successfully gave birth, but no difference was seen in tree damage between females in different reproductive conditions. Damage appears to be very individualistic even with available alternative forage.

Further analyses of terpene levels and stem carbohydrate levels are currently being conducted and are necessary before conclusions on mountain beaver selectivity of forage can be reached.

Effects of Forage Nutritional Quality on Deer Acceptance of Foods Containing Secondary Metabolites—Deer and other wild ungulates occur across the United States, providing desirable recreational and esthetic opportunities. Unfortunately, foraging deer can



cause conflicts with humans, in particular where population densities are high. Most, if not all, ungulate damage to forest resources is inflicted while animals are foraging for food. Deer food choices reflect preferences for nutritious forage and not merely relative abundance. Understanding why deer select some foods and avoid others may enable resource managers to manipulate their choices. Knowing how to reduce the deer's interest in eating seedlings would greatly enhance the ability to manage their negative impacts.

In general, herbivore diet selection is attributed to obtaining a balanced intake of nutrients and minimizing toxins or plant secondary metabolites. Proteins and energy are essential for survival while secondary metabolites can be deleterious to an animal's health, limiting digestibility of other nutrients, or at least requiring additional resources to detoxify toxins. An animal's ability to cope with toxins reflects not only the kind and amount of toxins but also the available nutrients in all forages offered.

A series of experiments was conducted to assess whether diets with varying levels of energy and protein affect deer acceptance of foods containing secondary metabolites. Deer exhibited a persistent preference for a high-energy–low-protein (HELP) diet compared to a low-energy–high-protein (LEHP) diet. Their initial preference for HELP may have been in part caused by their prior experience, as animals tend to select familiar rather than novel foods. Therefore, HELP similarity to the regular diet fed at the station may have initially affected their choice. However, this preference persisted throughout the experiment. Deer offered HELP and LEHP in the last multiple-choice test continued to ingest more HELP. However, when not offered an alternative, deer ingested the LEHP diet in amounts similar to the



amount ingested by deer offered only the HELP diet. These results suggest that deer exhibited a relative preference for HELP but not necessarily an avoidance of LEHP when choices were limited.

Within this experiment, deer in single-choice tests did not alter their intake of terpene- or tannin-treated food regardless of their base diet. Other studies reported animals ingesting more food containing toxins when they were permitted to regulate their macronutrients or were given a high-protein diet. The fact that deer did not show this response may be because deer respond differently than domestic ruminants or may reflect the experimental paradigm. Further efforts may provide better insights of conditions (e.g., experience, satiety or nutritional status, toxin or macronutrient concentrations) necessary to elicit varied responses.

Energy and protein availability did affect deer consumption of treated foods in multiple-

choice tests. Deer maintained on the LEHP diet consumed more terpene- and tannin-treated food than deer maintained on HELP or permitted to self-regulate between the two maintenance diets. This increase may reflect a greater tolerance for these toxins because of the high protein diet. Deer decreased their LEHP consumption when eating terpene- or tannin-treated food; therefore, an alternate explanation is that deer were compensating for their low preference for LEHP by ingesting more of the treated diets. All three treatment groups ate similar total amounts of food during both multiple-choice trials, so if they ate less LEHP they had to make up the caloric difference. It is difficult to ascertain whether deer increased their intake of tannins because of the protein-enriched diet or merely showed relative preferences. Deer demonstrated a greater willingness to ingest tannin-treated food than terpene-treated food, which may be because deer produce salivary proteins capable of binding to tannins and minimizing their deleterious effects on digestibility.

Potential Use of Zinc Phosphide Bait To Control Nutria on Louisiana Coastal Marshes

Marshes—Nutria, a large semiaquatic rodent native to South America, have been introduced around the world, primarily for their fur. They were first brought to the United States as early as 1899. Their dispersal was encouraged by promoters selling them as “weed cutters” and by fur farmers. Through escapes and intentional releases, nutria spread, and they continue to exist in 15 States. Their ability to adapt, their voracious appetite, and their high reproductive potential are the reasons why nutria are recognized as one of the top 100 worst invasive species in the world. Nutria damage to Louisiana’s coastal marshes has been an increasing concern. Herbivory by nutria is recognized as a contributing factor to the decline of native Louisiana coastal marshes by causing declining vegetative biomass and changing plant communities. The Louisiana Department of Wildlife and Fisheries is examining multiple approaches for reducing nutria’s detrimental impacts to native marsh and has requested NWRC assistance to examine the

potential for using zinc phosphide bait to control nutria on coastal marshes.

A series of studies was conducted to assess feasibility of baiting on coastal marshes and to develop approaches for attracting animals to bait stations. Specific objectives were to determine (1) the feasibility of using tetracycline and metallic flakes to monitor nutria foraging activity; (2) preferred foods for baiting nutria on coastal marshes; (3) nutria activity on rafts containing bait on coastal marshes; (4) potential of audio, olfactory, and ocular stimuli to attract nutria to bait stations; and (5) the susceptibility of nutria to zinc phosphide treated bait.

Tetracycline and metallic flakes appeared to be reliable indicators of bait ingestion. Nutria readily ingested sweet potatoes treated with tetracycline and metallic flakes. Tetracycline was detected in nutria teeth only 2 days after treatment. Its reliability to mark treated animals increased with time, and 80 percent of the treated animals were marked after 5 days.

Generally, tetracycline is used as a long-term marker with at least several weeks elapsing between feeding it to animals and subsequent tooth collection. Ingested metallic flakes went directly to the stomach and passed through the gastrointestinal tract over the next few days. Flakes passed through some animals very rapidly and were detectable in the lower intestine and feces the same day they were fed to nutria. However, flakes persisted in most animals for at least 2 days.

These markers appear to provide a feasible tool to detect which animals are feeding at bait stations and possibly how far they traveled to reach a station. Which station an animal visits could be determined by placing baits coated with different colored metallic flakes on each raft. How far animals travel to reach stations could be determined by collecting animals at varied distances from the station and subsequently determining which were marked. By combining flakes with tetracycline, the animals could be marked immediately with flakes and permanently by tetracycline.



Nutria use of bait stations during the late spring was poor. Only one raft was repeatedly visited—probably because nutria had ready access to other food as native vegetation was actively growing during the study and nutria readily consume numerous marsh plants. Early studies reported that baiting with 0.75-percent zinc phosphide reduced nutria populations by 95 percent. However, results of this test indicate that baiting on native marsh during the spring may be less efficacious. Baiting nutria on native marsh would probably be more effective during the winter when native forage is less abundant. Preliminary data from a study with eight rafts placed on floating marsh in the winter of 2003–04 showed that all of the stations had some nutria activity after a couple weeks of prebaiting.

Sweet potato proved to be the best bait of the three foods tested (sweet potatoes, apples, and carrots). Sweet potatoes were the most readily consumed bait in the field trial, and captive nutria regularly consumed almost all available sweet potatoes before eating apples or carrots. Sweet potatoes have the advantage of being generally accessible and cheaper than the other foods. Sweet potatoes also maintained their bait integrity better than carrots and apples when exposed to normal weather conditions (e.g., heat, rain). Carrots and apples both tended to turn soft after a few days in the heat.

The simple audio and visual stimuli we tested did not work well as attractants. Nutria were not attracted to recorded nutria calls, and there was a tendency for nutria to avoid or not respond to the calls. Nutria are gregarious, forming social groups, so perhaps calls are unique within a social group to help members maintain contact or to designate territorial boundaries for intruders. Unique calls, particularly if they signify territories, would be difficult to develop as broad-spectrum attractants. Nutria also appeared indifferent to caged conspecifics. Olfactory cues probably provide the best opportunity for developing an attractant because nutria did respond to odors by following an odor trail of nutria waste that provided a distinctive odor recognizable to nutria.

Eighty percent of the nutria offered zinc phosphide-treated sweet potatoes died within



24 hours. Although this is a significant number, researchers had anticipated 100-percent mortality. These animals had been prebaited with sweet potatoes every day for the previous couple of months, and prior to treating with zinc phosphide they were readily consuming sweet potatoes. Also, animals were food

deprived. Animals that survived probably did not ingest baits—a phenomenon that could be problematic in the field. Nutria offered bait under normal field conditions probably will have been prebaited for only a couple weeks and also will have access to alternative natural foods.

Project Title: Ecology, Behavior, and Management Methods for Predators To Protect Livestock and Wildlife Resources

Goal: Examine ecology, behavior, and management of predators in relation to depredations on livestock, game animals, and threatened and endangered species.

Data on predator population dynamics, ecology, and behavior in relation to predation patterns on species of human concern (mainly livestock, game species, and threatened and endangered species) are needed for effective depredation management. These data can also be used as a basis for developing accurate methodologies for indexing predator abundance and monitoring management programs. While much data exist, significant gaps remain with regard to predator-prey, predator-predator, and predator-livestock relationships. In addition, despite increasing interest in selective attractants for the delivery of pharmaceutical materials, repellants, and deterrent strategies that can reduce depredation, few practical attractants exist.

Selective Targeting of Alpha Coyotes with Audio Playbacks—Coyotes involved in livestock depredation are usually territorial dominant (alpha) individuals. The timely removal of one or both alphas from territories where depredation occurs effectively reduces losses. Alphas can be harder to remove with conventional means of capture than other coyotes in the vicinity of livestock, so control methods are needed that selectively target the alphas. One potential way to do this is with "calling and shooting" whereby a broadcast call simulates an intruder in a territory and attracts an alpha intent on driving the intruder out.

A recently completed study investigated factors affecting vocal and approach responses by coyotes of different social status to a variety of



different types of playback. Transient coyotes almost never vocally responded to playbacks. Territorial coyotes (alphas and betas) were much more likely to respond to group coyote vocalizations than to sirens, solo coyote vocalizations, or human imitations of coyotes or prey. Males vocally responded more than females, and responses were higher before sunrise when there was moonlight. Territorial coyotes were twice as likely to approach playbacks as transients and were more likely to approach playbacks of group howls than other types of playback. Approach rates were highest during the breeding and whelping seasons (January to June). It was not possible to determine whether alphas were more likely to approach than betas. Further research is needed to clarify this issue.

Chicago Urban Coyote Study—The distribution of coyotes has expanded throughout North America and into urban areas where there is a concern for human and pet safety. NWRC scientists examined the potential conflict that coyotes pose to humans by studying their landscape utilization and food habits in the Chicago metropolitan area during 2000 through 2002. Coyotes in developed areas had



home-ranges twice the size of coyotes in less-developed areas. Nonurban habitats were used by all coyotes for resting and foraging, while urban land was either avoided or used for traveling. Large home-ranges, high amounts of urban land, and a preference for nonurban habitats forced coyotes in developed areas to travel through urban land exposing themselves to human activities. However, coyotes in developed areas avoided nocturnal periods with high human activity, thus reducing conflicts with humans. Coyotes in less-developed areas

did not appear to be affected by human activity at night.

Dominant food items from dietary analyses included small rodents, white-tailed deer, fruit, eastern cottontail, and birds. The percent occurrence and availability of these food items varied among collection sites and seasons. The occurrence of human-associated food items, which was found in significant amounts only in the developed site, ranged from 2 percent during the breeding season to 25 percent

during the pup-rearing season. Based on the utilization of human-associated food items, coyotes in developed areas may have a higher potential for conflicts with humans than those in less-developed areas. However, because coyotes in less-developed areas had a lower dietary diversity and relied more on a limited number of prey species, these coyotes may venture into developed land if there is a drop in the abundance of a major prey species.

Project Title: Alternative Capture Systems and Aversive Stimulus Applications for Managing Predation

Goal: Identify, develop, and evaluate advanced capture systems and aversive stimuli applications for predation management, emphasizing animal behavior and engineering approaches.

In Europe and the United States, large predators are returning to former habitats now occupied by people and livestock. Public and professional concern for animal welfare and a simultaneous requirement for a stable and affordable food supply have led to intense pressure on wildlife managers to find immediate solutions when humans and wildlife adversely interact. However, capture technologies are largely reliant on tools and materials developed hundreds and thousands of years ago. These older technologies are still widely used because of their effectiveness and because few other options are commercially available. This project is attempting to develop new and alternative techniques to minimize adverse interactions between predators and livestock.

Operational Use and Evaluation of the Radio Activated Guard—Biologists from the NWRC Logan, UT, field station and Idaho WS have been gathering data on the use of Radio Activated Guard (RAG) devices for non-lethal control of wolf predation. The RAG consists of a scanning receiver programmed to scan for predetermined radio frequencies generated by radio collars on nearby wolves. The device can be set to cover an area within a radius of 20 to 300 m. Activation of the device triggers a strobe light and loud sound effects from a tape player. To reduce the ability of animals to habituate to the device, there are 30 different recorded sounds, and each time it triggers a different sound is played.

The RAG is now commercially available and is being purchased, promoted, and employed by WS operations with support from nongovernmental organizations such as Defenders of Wildlife. To date, 11 devices have been produced and deployed. The RAGs were used successfully to protect cattle on private lands in Idaho from repeated incursions by wolves. After numerous months of deployment, the RAGs stopped serving as a deterrent to livestock predation in one pack because its wolves habituated to the devices. However, this nonlethal technique was effective for a longer duration than any previous technology. The use and testing of the RAG boxes by WS continues, as does the integration of the devices into predepredation, proactive wolf management.

Effectiveness of a Movement-Activated Guard and Fladry Under Experimental Conditions

—Because the RAG is limited to activation by radio-collared predators, NWRC scientists have developed a Motion Activated Guard (MAG). The MAG device activates when a predator comes within a 20- to-50-foot range and plays 30 different sound effects that include helicopters swooping, people yelling, and gunfire while flashing a bright strobe.

The MAG was tested in Gordon, WI, by a team that included cooperators and collaborators in WS, the Wildlife Science Center, and Conservation International. The study used an experimental approach to examine the effectiveness and longevity of effectiveness of behavior-contingent disruptive stimulus devices and fladry (i.e., hanging strips of flagging to deter predators from entering an area) to dissuade predators (wolves, bears, and raptors) from consuming a food resource. Results showed that the multiple stimuli and behavior-contingent activation of the MAG device best repelled predators from the food resource.

Bear Alarm To Help Manage Problem Black Bears in Yosemite National Park

—Black bears that shred tents and peel open car doors in order to get food from campers continue to be a significant concern for Yosemite National Park biologists despite an ongoing program to reduce conflicts with



bears by using nonlethal hazing techniques. In an effort to enhance the effectiveness of these hazing efforts, researchers from NWRC, in cooperation with Yosemite National Park and the Wildlife Conservation Society, have developed an alarm system that alerts park personnel to the presence of problem black bears in developed areas (campgrounds and parking lots). Park personnel are then able to respond more quickly to problem animals and reduce the amount of damage done and the amount of food attained by bears.

The remote alarm system utilizes radio-telemetry technology to continually monitor

designated areas. When a bear is detected, the system sends out a message through the park radio infrastructure alerting personnel that a bear is in a particular developed area. Rangers head for the scene and shoo the bear away with noise, bright lights or, in stubborn cases, bean bags or rubber bullets. In 1997, improper food storage in Yosemite contributed to nearly \$600,000 in bear-caused property damage, and bears broke into more than 900 cars. The use of this new technology increased bear sightings fourfold and has helped to reduce damage and educate bears to stay away from populated areas.

Project Title: Holistic Management of Rodents and Other Introduced Vertebrate Pest Species in Hawaii

Goal: To develop safer and more effective methods to reduce the agricultural, natural resource, and human health impacts of rodents and other introduced pests in Hawaii.

Rats and other invasive species cause significant agricultural, natural resource, and human health impacts to the Hawaiian Islands. Current control techniques provide inconsistent levels of protection from these impacts. NWRC biologists conduct field and laboratory research to identify, evaluate, and improve methods, materials, and devices to reduce and monitor vertebrate pests and invasive species impacts on Hawaiian crops and natural resources. Information brochures, an educational outreach program, and research posters are all being used to provide information to the public and the agricultural community.

Eleutherodactylus Frog Control on Hawaii—Two species of *Eleutherodactylus* tree frogs, accidentally introduced to Hawaii via imported nursery products, have rapidly spread throughout the Hawaiian Islands. These pests are a serious quarantine concern to the export nursery industry, pose a potential threat to native invertebrates by predation, threaten

birds by competing for food, and are a significant nuisance problem to residents and tourists due to their extremely loud, nighttime mating calls.

The Hawaii field station has conducted extensive screening of various registered ornamental horticultural pesticides, household products, and pharmaceutical chemicals to effectively control these pests. Two successful tools have been developed to control frogs, caffeine, and citric acid. The use of citric acid has been critical in controlling frogs because it does not have the registration restrictions of caffeine, so it may be used by the general public. The Hawaii field station staff has been heavily involved in conducting research in support of an environmental assessment so citric acid may be used by the WS operational program. Field station staff have also been involved in education and outreach by meeting with the community and developing educational material.



Broadcast Applications of Rodenticides Evaluated in Hawaii—In support of the Hawaiian conservation community, the Hawaii field station has completed an assessment of the optimal (minimum) sowage rate and efficacy of broadcast applications of rodenticide baits in native Hawaiian conservation areas using placebo bait pellets treated with a non-toxic biological marker. To ensure that this technique of rodenticide application does not pose undue risk to Hawaiian natural resources, NWRC completed a field assessment of the

nontarget risk of the broadcast application of rodenticide baits to forest birds in native Hawaiian conservation areas. A field study on diphacinone residues in slugs and snails consuming the rodenticide Ramik® Green has also been completed and a hazard assessment developed. This hazard assessment revealed that the diphacinone residues in slugs and snails pose little risk to native birds.

NWRC scientists also evaluated the potential nontarget effects of diphacinone on feral pigs during an aerial rodenticide application. Eaton's Bait Pellet Rodenticide with Fish Flavorizer®, which is highly attractive to wild pigs, was applied to a forest area. Wild pigs were attracted to this formulation and died after consuming bait. Further research is needed to test other formulations that are not as attractive to pigs.

NWRC Develops New Mongoose Tracking Station—In August 2004, scientists from the NWRC Hawaii field station completed development of a new tracking tunnel designed specifically for mongoose. The tunnels in use previously had been designed for rodents and did not provide reliable data on mongoose use. The new tunnels are longer and still exclude other mammals, such as feral cats. These tunnels are easier to set up, weather resistant, and cost less than \$1.00 each, allowing for greater deployment. They will be used to monitor mongoose activity in sensitive areas that currently do not have documented mongoose populations.

Project Title: Development and Assessment of Methods and Strategies To Monitor and Manage Invasive Mammalian Species With an Emphasis on Rodents

Goal: Review the current biological status of established and potential invasive mammalian species, with an emphasis on rodents, in the United States and its territories, and investigate promising methods and strategies for surveillance, management, and eradication.

Large numbers of invasive (nonnative) animals have become established in the continental United States, its territories, and nearby countries and islands. The United States has at least 221 nonnative terrestrial vertebrate species, of which about 20 species of invasive mammals have become established. These include fish (grass carp, tilapia, walking catfish), reptiles and amphibians (brown treesnake, cane toad, Caribbean tree frog), birds (myna, monk parakeet, mute swan, starling, pigeon) and mammals (feral livestock, dogs, cats, mongooses, rats, and nutria). Invasive vertebrate species cause substantial damage to crops and livestock, property, and natural resources (including threatened and endangered species, biodiversity, and ecosystem health), and pose a disease hazard to humans and livestock.



Rodent Control on Aleutian Islands—

Introduced rats are causing high mortality to protected, nesting seabirds in the Aleutian Islands of Alaska. The U.S. Fish and Wildlife Service (FWS) is designing a program to eradicate the rats from many of the islands of the Alaskan Maritime National Wildlife Refuge. With support from FWS, a scientist from NWRC in Fort Collins designed and conducted a field study to test the efficacy of a hand-broadcast bait application of a diphacinone rodenticide pellet on a 4-ha area of the island and to learn more about the rats of Kiska Island.

Twelve people helped set it up, but a crew of four weathered the locally harsh conditions for 6 weeks in April and May to complete the study. The rats were already feeding heavily on seabirds and, consequently, were hard to lure to tracking stations, chew sticks, and traps set within trap stations. All female rats captured were pregnant with 9 to 10 embryos, showing a very high reproductive performance when conditions provide an abundant, nutritious food source.

It appears that when the birds are not present, or in areas away from the bird nesting colonies, rats do not fare well, but some subsist on invertebrates and seaweed. The pelleted diphacinone bait was readily taken by rats and seems to have controlled rats on the treated plot, where signs of rat presence decreased about 85 percent versus a decrease of only 17 percent on the control plot. It is anticipated that this successful approach to rat control will be adapted to aerial application by helicopters working off ships to treat entire islands.

PRODUCT DEVELOPMENT RESEARCH PROGRAM

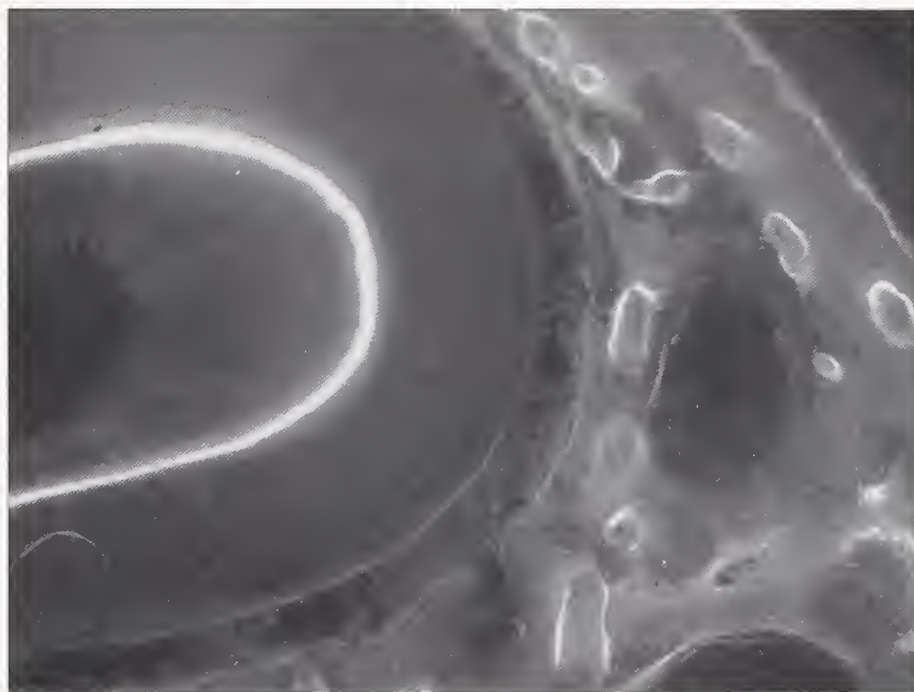
Project Title: Development of Chemistry-Based Tools for Wildlife Damage Management

Goal: Develop chemistry-based techniques and tools that fulfill the research needs of WS.

The approach to developing chemistry-based tools is based on increasing the understanding of the chemical and biochemical aspects of wildlife damage. Analytical chemistry forms the foundation of much of the research conducted under this project. Project scientists have experience in related scientific disciplines, such as metabolism chemistry, environmental fate, chemical synthesis, toxicology, chemical ecology, wildlife genetics, and chemical formulation. Project personnel also initiate and/or collaborate with other NWRC scientists on a variety of studies that contribute to development of wildlife management tools.

Quantification of Tetracycline Biomarker in Rabies Vaccine Bait Blocks

Blocks—In 2003, USDA participated in the domestic distribution of more than 10 million rabies vaccine baits. Tetracycline is added to these baits as a biomarker and can be detected in the teeth of animals that consume the baits. Significant discrepancies between the presence of the tetracycline biomarker and vaccine antibodies in raccoons collected in baited areas suggested a need for quantifying the tetracycline biomarker in the baits. The analytical chemistry project developed the required analytical methods and quantified tetracycline in raw ingredients and manufactured baits.



These analyses indicated that approximately 30 percent of the tetracycline is converted to epitetracycline during the manufacturing process. Additional studies indicated that about 20 percent of the tetracycline and 50 percent of the epitetracycline in each bait are bound in the plastic polymer used to hold the bait ingredients together. Finally, feeding studies with raccoons indicated that epitetracycline is only one third as effective as tetracycline with respect to its ability to mark raccoons.

Cumulatively, these studies indicate the rabies vaccine baits contain the equivalent of 86 mg of free tetracycline rather than the target quantity of 150 mg tetracycline. This difference would likely have a negative impact on the ability to detect the biomarker in large raccoons that had consumed the vaccine baits.

Development of a Controlled-Release Predator Lure—A controlled-release formulation comprised of gelatin, modified starch, and glyceraldehyde has been developed for use with the M-44 delivery system. The new lure is compatible with a wide variety of synthetic and natural attractants and is usable at temperatures up to 140 °F. A new mold was developed to produce lures directly on the M-44 capsule holder. As preparation is

straightforward, molds can be prepared under field conditions.

Preliminary reports of field uses have been positive. The new M-44 lures were also tested with captive coyotes. Acceptance of the new lure with a synthetic attractant was high, and associated use with prebait could increase efficacy.



Project Title: Economic Research of Wildlife-Caused Agricultural, Public Health, and Natural Resource Impacts

Goal: Quantify the benefits and costs of NWRC products and WS activities that aim to mitigate the impacts of wildlife diseases, wildlife damage to agriculture and natural resources, and wildlife risks to public health and safety.

This research is attempting to quantify benefits and costs of both traditional and new wildlife management activities, such as intervening with repellants, relocations, removals, and rodenticides to limit the adverse effects of wildlife on agriculture, natural resources, and human health and safety.

The Economics of Rabies—Fewer than three or four human deaths occur annually from rabies in the United States. Still, this disease poses a major economic and public health concern. Diverse costs are incurred by municipal governments, insurance agencies,

and private citizens due to human or domestic animal contacts with suspected rabid animals.

Recent data show that rabies cases involving pet dogs and cats account for only 5 to 10 percent (<500/year) of all animal rabies cases in the United States, whereas the incidence of rabies in wildlife has increased dramatically in the past decade (7,967 cases in 2002). Rarely are wildlife captured and quarantined after a suspected human contact. This adds substantially to wildlife-rabies-induced costs because most physicians will implement the complete medical postexposure prophylaxis (PEP) series as a precaution.

In 2003, NWRC researchers collaborated with California Department of Public Health staff on an economic study of the costs of rabies in southern California. The study was approved by the Committee for the Protection of Human Subjects, California Department of Health Services. Public Health and various hospital/clinic records for the period 1998–2003 in San Luis

Obispo and Santa Barbara counties were gleaned for cases of rabies PEP treatments, health services, and animal control activities. Researchers examined the records of 134 people who received PEP (87 in San Luis Obispo and 47 in Santa Barbara). Next, researchers conducted telephone interviews with 55 volunteers whose patient records came from this initial set of 134 cases.

The total mean per-patient cost for a suspected rabies exposure was \$3,345.69 (range \$673–\$8,355) in 2003 dollars. This cost was further broken down to estimate the direct costs (e.g., rabies vaccine, medical treatments) and indirect costs (e.g., public health investigations, lost wages, payments for child care).

Direct costs averaged \$2,254.17 (range \$267–\$5,673) per case; indirect costs averaged \$1,091.52 (range \$406–\$2,662) per case. On average, \$121 and \$290 were spent for public health and animal control officers, respectively, to deal with each case. The 5-year, 2-county



cumulative costs, including rabies tests for 468 suspected rabid animals, totaled \$585,523.

Cooperation Among NWRC and Universities To Conduct Economics Research

Research—Environmental economics is a rapidly growing field within economics. During 2000 through 2003, NWRC funded an initial project with the goal of conducting benefit-cost analyses of specific research and WS activities aimed at reducing monetary losses from wildlife damage to crops and natural resources. This effort was viewed as important to future goals of NWRC and WS, and the Center hired a research economist in 2003.

In 2004, a cooperative venture was begun with the Economics Department at CSU. The Department sought project opportunities for its graduate students in environmental economics and related fields to gain applied research experience related to wildlife, agriculture, and natural resource issues. Under this agreement, CSU and NWRC will work together to match promising young scholars with applied economics research assessments to mutual advantage. This cooperative venture will provide a mechanism for greater NWRC-CSU collaboration.

Benefit-Cost Ratios of Feral Swine Removal

Removal—Savannas Preserve State Park in Florida protects the last remnants of a basin marsh system that formerly extended for 200 miles along Florida's southeastern coast. The rest of the marsh has been lost to development. This park also supports myriad threatened and endangered plant and animal species. The exposed portions of the marsh have been severely damaged by feral swine.

In January 2003, collaborative work with WS and the Florida Department of Environmental Protection was undertaken to estimate the amount and value of the swine damage per hectare to the exposed portions of the basin

marsh prior to swine removal. After 1 year of swine removal, the amount and value of damaged marsh were again estimated.

Prior to swine removal, 19 percent of the exposed portions of the basin marsh had been damaged by swine, and the value of the damage to the sampled portion alone was between \$1.2 and \$4 million. After a year of swine removal, damage was down to 7 percent. The sampled portion was estimated to have incurred damage costing between \$235,000 and \$767,000. This represented a return of between \$1 million and \$3.3 million for swine removal costs.

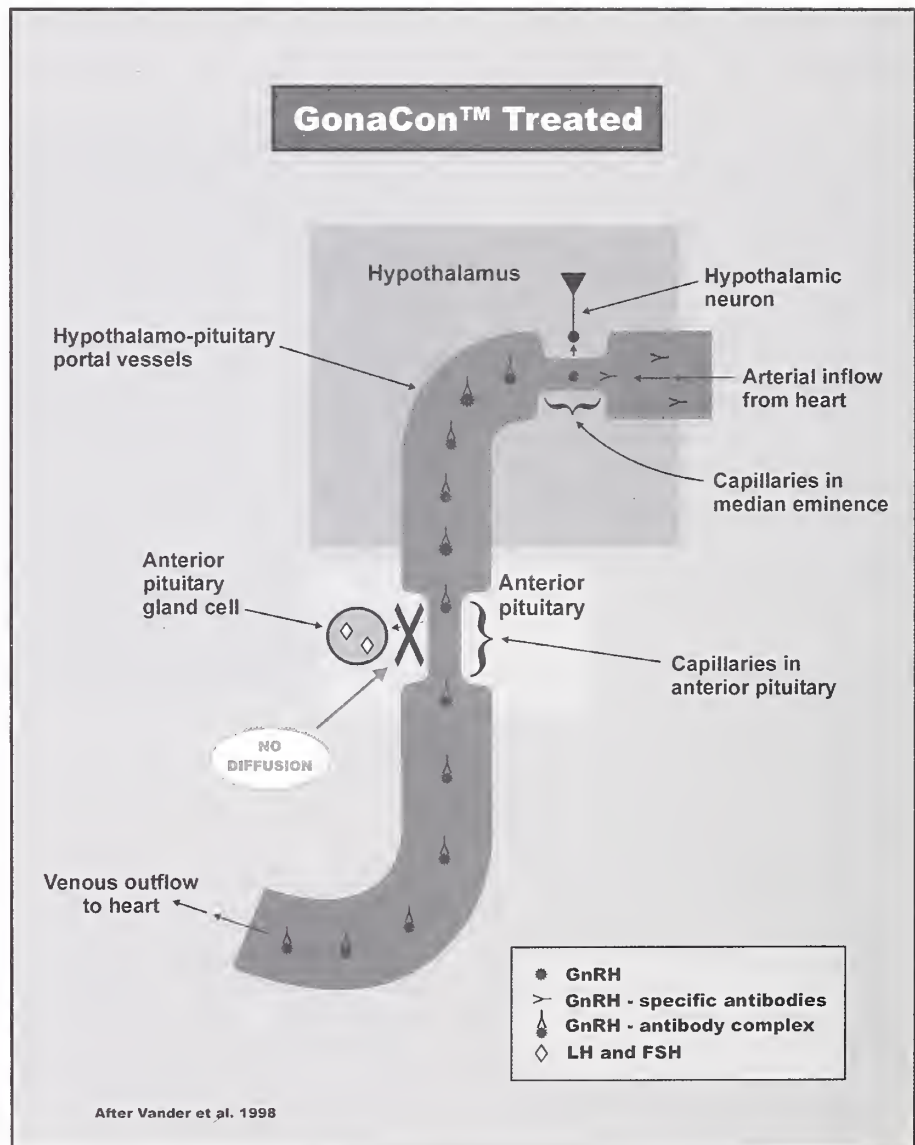


Project Title: Development of Reproductive Control Methods for Overabundant Birds and Mammals

Goal: To obtain FDA approval for use of porcine zona pellucida (PZP) and gonadotropin-releasing hormone (GnRH) immunocontraceptive vaccines for white-tailed deer and to develop new oral contraceptive agents for use in controlling reproduction in overabundant avian species (e.g., monk parakeets and crows) and in mammalian species (e.g., California ground squirrel and prairie dogs).

The WS program has given high priority to research on reproductive control of various species of mammals and birds involved in human-wildlife conflicts. Results of the research can then be used to develop alternative management tools.

Deer Population Control and Reduction of Human-Deer Conflicts Through Immunocontraception—Locally overabundant deer herds, particularly those inhabiting fenced or other enclosed areas in urban or suburban settings, are presenting serious problems for wildlife managers, landowners, and the general public. Problems associated with deer overabundance include increased numbers of collisions between deer and motor vehicles, increased frequency of other deer-human conflicts (e.g., damage to ornamental plantings, aggressive behavior toward humans by bucks during the rut), greater potential for disease transmission among deer, reduced nutritional status of deer, and damage to local native vegetation due to overbrowsing. Traditional methods of population control such as regulated harvest by licensed hunters often are impractical or illegal in such settings. The development of safe and effective wildlife contraceptives is needed to control locally overabundant populations of deer and other wildlife in situations where traditional management tools cannot be employed.



NWRC researchers in Fort Collins have been active in the development and testing of wildlife contraceptive agents since 1992. To be an effective and useful wildlife contraceptive, a compound should (1) be safe for the target animal and free of undesirable side effects, (2) not affect nontarget species adversely, (3) not cause treated food animals to become unsafe for human consumption, (4) cause little or no negative social effect on target animals, and (5) induce complete and long-lasting infertility that, ideally, is reversible. Many compounds have been tested at NWRC, including some that were highly effective in sterilizing wild mammals and birds. Problems associated with some of these materials, however, precluded their use in many management situations. Common problems included undesirable side effects, difficulties with delivery systems, and the danger of dosing nontarget species. In some cases, a contraceptive agent may cause undesirable reactions in one target species but not in others.

NWRC scientists have developed a new immunocontraceptive vaccine (named GonaCon™) that shows great promise as a wildlife infertility agent. Two major obstacles had to be overcome during the development of this vaccine. First, a new adjuvant had to be developed. An adjuvant is an immunologic agent that is added to a vaccine to increase the immune response. A replacement for the commonly used Freund's adjuvant was needed because the U.S. Food and Drug Administration (FDA) has objected to its use on several grounds, including concerns related to target animal safety and human consumption of treated animals. Accordingly, NWRC scientists developed a new adjuvant (called AdjuVac™) that is more effective than Freund's adjuvant and lacks the negative side effects.

The second major obstacle to the development of a new immunocontraceptive vaccine for wildlife was the need for a single-dose contraceptive because of the impracticality of

capturing free-ranging wild animals twice to vaccinate them. Previous contraceptive vaccines required at least two injections (an initial dose followed by a booster dose). Although it was originally developed as a two-injection contraceptive treatment, NWRC's GnRH vaccine was subsequently tested in a single-injection form that is much more practical as a field delivery system for use on free-ranging animals. Development of the single-injection vaccine was possible only because of the creation of AdjuVac adjuvant.

The usefulness of a single-shot immunocontraceptive vaccine depends, among other things, on the duration of the contraceptive effect that the vaccine produces. The combination of AdjuVac adjuvant and NWRC's GnRH conjugate produces a much longer lasting contraceptive effect than was produced by earlier efforts that combined Freund's adjuvant with the (same) GnRH conjugate.

Recent studies with free-ranging California ground squirrels, captive Norway rats, feral cats and dogs, domestic and feral swine, wild horses, and white-tailed deer have demonstrated the efficacy of the single-shot GnRH vaccine as a contraceptive agent. Infertility among treated female swine and white-tailed deer, for example, lasted up to 2 years without requiring a booster vaccination.

Ongoing studies initiated during July 2004 are examining the practicality of administering GonaCon to free-ranging white-tailed deer as well as the efficacy, toxicity, and safety of the vaccine. Near Silver Spring, MD, an overabundant herd of white-tailed deer on a completely enclosed site that is owned by GSA has provided an excellent opportunity to test the efficacy and practicality of GonaCon on a free-ranging deer population. In this field study, 28 adult does were captured, equipped with ear tags and radio-telemetry transmitters, and injected with GonaCon immunocontraceptive vaccine. The reproductive behavior and perfor-

mance of these does will be monitored for 2 years and compared with those of 20 to 30 adult does (unvaccinated, control animals) that inhabit an adjacent, enclosed parcel of similar habitat. NWRC scientists are working closely with Maryland WS to complete this field study.

In an ongoing study of captive white-tailed deer at a Pennsylvania university, NWRC researchers are collaborating with the faculty to assess the toxicity and safety of GonaCon. Responses of treated and control groups of deer will be compared via analyses that will include blood chemistry, hematology, and histopathology, as well as assays of circulating progesterone, luteinizing hormone, and GnRH antibodies.

No fertility control agents have been approved by FDA for noninvestigational use on wildlife populations in the United States. Several materials, however, including GnRH and PZP vaccines, have been classified as investigational drugs that may be used (only) in rigidly controlled research studies.

The two GonaCon studies underway in Maryland and Pennsylvania are being conducted as pivotal studies that are required as part of FDA's approval process for a new animal drug. The approval process for GonaCon vaccine began in 1998 when FDA established an Investigational New Animal Drug (INAD) exemption for GnRH vaccine. All research studies of GnRH vaccine have been conducted under this exemption (INAD-10006). A development plan for GonaCon was prepared by NWRC staff during June 2004. The plan provides guidance for NWRC's efforts to pave the way for private-sector companies to produce and distribute the vaccine.

NWRC scientists are hopeful that the GnRH vaccine will soon be approved for use for wildlife fertility control. GnRH vaccines have an advantage over PZP because they prevent eggs from being released from the ovaries, thereby

eliminating estrus and some undesirable behaviors (e.g., bucks chasing does across roads) associated with estrus.

GnRH vaccine holds promise for reducing or eliminating certain undesirable behaviors in companion animals, too. For example, fighting, scent-marking, caterwauling, and wandering by cats and unruly behavior in horses could be reduced by GnRH vaccine because it indirectly blocks the production of sex hormones (e.g., estrogen and testosterone), which contribute to the expression of such behaviors.

The single-shot, multiyear vaccine will be a useful technique for the management of enclosed or urban or suburban deer populations. However, GonaCon still has limitations, especially the need to capture and inject each animal. NWRC scientists hope eventually to produce an oral GnRH vaccine that will be attractive to the target species but unlikely to be consumed by nontarget animals. For additional information regarding GonaCon and other infertility agents being researched at NWRC, please visit our Website at <<http://www.aphis.usda.gov/ws/nwrc/research/immunocontraception.html>>.

Development of a New Electronic Mortality-Monitoring Alarm System—

A researcher from NWRC in Fort Collins has developed a mortality-monitoring alarm system that will be used during the 2-year GnRH field efficacy study in the deer herd at White Oak Research Facility in Silver Spring, MD. Control deer and deer injected with the GonaCon vaccine will be instrumented with radiotransmitters. The newly developed automated mortality-monitoring alarm system, centrally located at the White Oak facility, will alert Maryland WS personnel, via the cellular-phone network, if mortality occurs among transmitted deer.

This unique system employs a digital transmitter/receiver design, which greatly increases the range of an automated data-logger monitoring system. The system logs live animals continuously, and all data can be downloaded and analyzed. If a deer dies, the logger then activates the cellular-phone network with a voice alarm, indicating a death has occurred. The time from actual death of the animal to the alarm cellular-phone call is as near to real time as transmitter design will allow without false mortality signals being generated; thus, the system allows field personnel to locate the animals quickly and gather cause-of-mortality data before environmental and other factors may interfere with accurate data collection. The system is solar powered and has application across a broad variety of study designs.

Testing of DiazaCon® (20,25 diazacholesterol) in Waterfowl—

NWRC researchers are working to develop a variety of fertility-control methods so solutions can be matched to specific needs in the highly variable conditions found in problem wildlife situations. One of the contraceptive com-

pounds being studied is 20,25 diazacholesterol (DiazaCon). The compound was previously registered with EPA for pigeon control under the name Ornitol®. DiazaCon has cholesterol-lowering activity and contraceptive effects in both birds and mammals. DiazaCon is a cholesterol inhibitor that blocks the conversion of desmosterol to cholesterol, resulting in lowered cholesterol levels and increased desmosterol levels. While reproductive success cannot be readily measured in captivity, cholesterol and desmosterol levels can be measured as indicators of success.

The Canada goose is a species that causes problems due to overabundance in certain areas, especially in urban locations, where they are sometimes year-round residents. A study was designed using mallards as a waterfowl model because mallards are easier to breed in captivity and closely related to the Canada goose. Female mallards were divided into four groups for the study. DiazaCon treatment was done by mixing the compound in feed and providing the feed as the only food choice. The control group was given feed with no DiazaCon



added. The other groups were given different levels or different time courses of treatment. Blood was obtained from each bird every 2 weeks to monitor the effects of treatment, and biologists weighed the feed each day during treatment to estimate average consumption per group. The birds fed treated feed ate less than the control birds.

Cholesterol levels began to drop by day 2 after the initiation of treatment, but the levels did not show a statistically significant difference until 2 weeks later, when the levels had dropped substantially. The levels of cholesterol remained low for several months with a gradual return toward control levels. The dramatic decrease in cholesterol levels was seen in all three treatment groups. Desmosterol levels were undetectable prior to treatment but increased after treatment and continued to rise even after treatment was completed, remaining high for several months. The levels were still not dropping at the time NWRC terminated the study.

These results indicate that DiazaCon can be given at effective doses by free feeding over a short period of time, and the effects last for several months. DiazaCon looks like a promising candidate for use in Canada goose contraception.

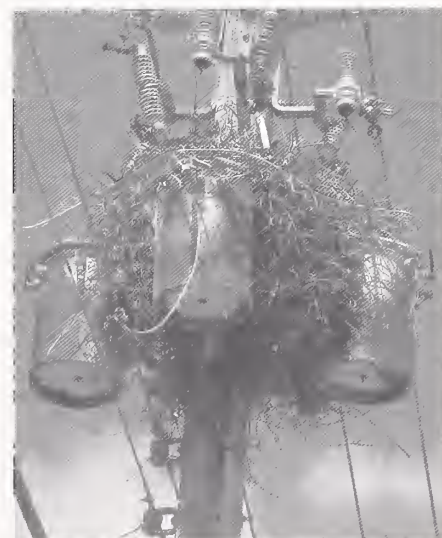
Evaluation of an Oral Contraceptive for American Crows—A study investigating the potential of DiazaCon as an oral contraceptive for American crows was begun in the fall of 2003. Forty-four crows were captured in Oklahoma and brought to NWRC for testing. Three different dose levels of DiazaCon were tested (50, 75 and 100 mg/kg). Crows were orally gavaged with a liquid solution of DiazaCon once a day for 14 days. Blood samples were obtained each week, and the plasma was analyzed for cholesterol and desmosterol levels.



Results showed no significant difference in cholesterol or desmosterol levels between any of the three treatment levels, but a significant difference between the treatment groups and the control group. Based on these results, the lowest dose of 50 mg/kg was chosen as the dose to test with treated bait.

A small pilot study was conducted to determine the best vehicle for delivery of DiazaCon. Raw eggs, boiled eggs, and scrambled eggs were tested. Birds displayed no significant preference among the bait types. Scrambled eggs were chosen for testing as they are less likely to be cached in the wild. An ad libitum study was begun in May 2004 to determine bait palatability and absorption of DiazaCon when fed in a scrambled-egg bait. Thirty-three crows were captured in Oklahoma and brought to NWRC. Crows were fed treated or untreated scrambled eggs for 14 days, and blood samples were taken weekly for cholesterol and desmosterol analysis. Results show good effectiveness, so the contraceptive will be tested in the field in 2005.

Evaluation of an Oral Contraceptive for Monk Parakeets—DiazaCon is also being studied for use in population management of monk parakeets and waterfowl. Monk parakeets are an invasive species from South America that build large, multiroom nests of twigs and other materials in trees, street lamps, utility poles, and other structures. A study investigating the potential of DiazaCon as an oral



contraceptive for monk parakeets was begun in the spring of 2003. Based on results from an initial oral gavage study, a 50 mg/kg dose was chosen for further testing. Another gavage study testing different lengths of treatment was conducted in the fall of 2003. Parakeets were orally gavaged daily for either five or ten consecutive days. Based on this study, a free feeding study was initiated in May 2004. Parakeets were fed DiazaCon treated seeds ad libitum for five days. Fecal samples were collected for analysis of fecal steroids. Results so far look positive, and nesting behavior and reproductive success are currently being monitored.

Evaluation of Three Contraceptive Approaches for Population Control of Wild Horses—

Overpopulation of feral horses in Nevada and other Western States is an increasing problem. In Nevada, feral horses under state control number about 1,200 in an area of 145,687 ha. This number represents 2 to 2.5 times the number of horses suitable for the habitat available. Such overpopulation creates problems with competition among the horses and indigenous plant and wildlife species, as well as with ranching interests. In addition, expanded movement of people wishing to live within the feral horse ranges creates conflicts. Historic and cultural importance of the feral horses engenders sympathy towards maintaining their populations, and slaughter of excess wild horses by government agencies is prohibited by the Wild Horse and Burro Act. Adoption programs have not kept pace with increasing horse numbers and can lead to mis-handling by well-intentioned but inexperienced adopters.

Reduction of free-ranging horse populations by limiting fertility holds the greatest promise



for humane and effective population control. Contraception in feral horses ideally should be safe, potentially reversible, and efficacious for several years with minimal handling required and should not affect normal reproductive and harem-maintenance behavior.

NWRC has been conducting research on contraception in feral horses in collaboration with the Nevada State Veterinarian and researchers from a Pennsylvania university. Scientists have tested a single-shot GnRH immuno-contraceptive vaccine, a single-shot PZP immunocontraceptive vaccine, and intrauterine devices (IUDs) for their potential as long-term, reversible contraceptives.

For this study, the Nevada Department of Agriculture maintained feral mares in corrals in natural harem conditions near Carson City, NV. Fifteen mares were assigned to each of the

following groups: control (untreated) or those receiving Copper "T" IUD, PZP vaccine, or GnRH vaccine. The wild horses were routinely observed for specific breeding and harem-maintenance behaviors and were monitored with ultrasound for IUD retention, pregnancy, and uterine inflammation.

Results of the first year of study indicated that both vaccines and the IUD contraceptive approaches were successful in preventing pregnancy in a high percentage of mares. Both PZP and GnRH vaccines were 100-percent effective in preventing conception. The IUD contraceptive was 80 percent effective; however, 20 percent of the IUDs were lost. None of the horses that retained the IUDs conceived.

These studies suggest that one or all of these approaches to limit fertility may be valuable in controlling populations of wild horses.

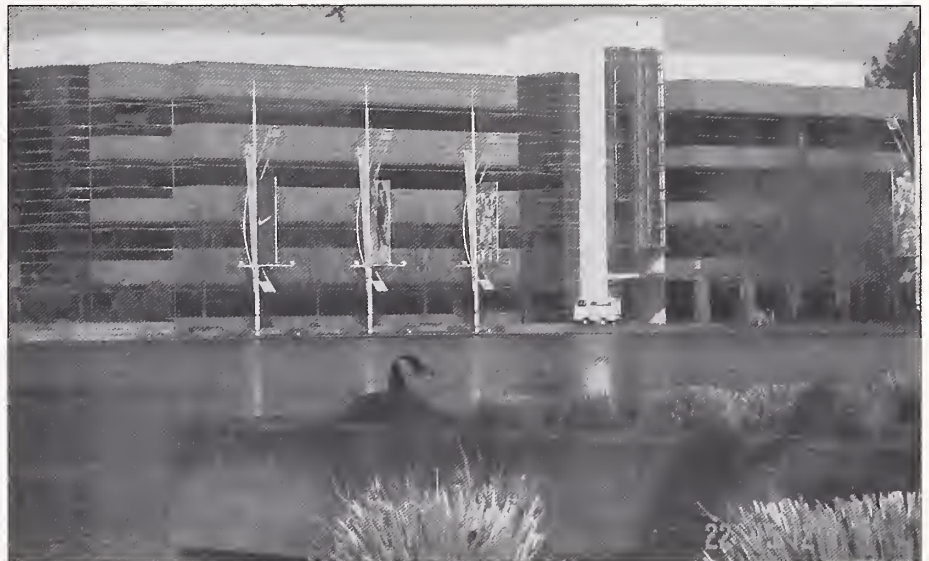
Project Title: Development of an Avian Infertility Tool for Application in Goose Management

Goal: Test the effectiveness and develop for use the contraceptive nicarbazin for reproductive control of geese.

As goose populations and urban areas expand and overlap, Canada geese are often considered a nuisance and potential health problem (fouling land and water, colliding with and damaging aircraft, etc.). Nonlethal and humane means of managing the size of Canada goose flocks residing near or on airports, golf courses, industrial parks, government sites, and city parks are needed. Nicarbazin may offer a way to limit Canada goose populations. It is a compound traditionally used in broiler chickens to prevent the disease coccidiosis, but decreased egg production and hatching rates are both seen as side effects. It appears that one mechanism by which nicarbazin exerts its effect on reduced viability of eggs is by causing disruption of the vitelline (yolk) membrane, allowing the yolk and albumin to flow together, creating conditions under which the embryo cannot develop. Research to develop nicarbazin as a contraceptive agent for Canada geese continues at NWRC, with both pen and field studies ongoing.

Nicarbazin Bait Field Effectiveness

Study—An extensive field study to test the effectiveness of nicarbazin in reducing the hatching of Canada goose eggs was conducted in the spring of 2004 in Oregon. Scientists at



the NWRC worked in cooperation with a private firm and with Oregon WS Operations to plan and conduct the field trials. Study sites were recruited in the winter/spring of 2002–03. Meetings were held at each site to provide information about nicarbazin and the purpose of the study, and APHIS WS personnel answered the public's questions. Each site then decided whether or not it wished to participate in the study. Meetings were also held with local Audubon Society chapters to provide information and to address any concerns local bird-conservation groups had about study activities.

During the 2003 nesting season, sites were visited and nests were recorded using geographical positioning system (GPS) devices to allow creation of geographic information system (GIS) maps of each site that show nest locations. GIS nest-location maps were then used to help researchers select optimal bait

sites and to allow more proficient monitoring of nests. An Environmental Assessment and Finding of No Significant Impact were finalized in December 2003. Fourteen field employees were hired in January 2004 to help conduct the field effectiveness study. It was initiated in February 2004 at 10 sites in Oregon—5 sites on each side of the Cascades, with 2 control and 3 treated sites per side. Data collection was completed in May 2004, and data analysis is ongoing.

A minimum 50-percent reduction in the percent hatchability of eggs laid by resident Canada geese at treated sites compared to the percent hatchability of eggs at control sites will be considered supportive of EPA registration of nicarbazin as a reproductive control agent for use in Canada geese. A private company, Innolytics, LLC, is attempting to obtain an EPA registration for nicarbazin to manage urban Canada geese.

Project Title: Field Evaluation of Chemical Methods for Brown Treesnake (BT) Management

Goal: Develop techniques to help control the BT on Guam and prevent its dispersal from that island.

The BT, a species accidentally introduced to Guam, has decimated that island's native fauna and poses a similar threat to other Pacific island ecosystems. NWRC scientists are field-testing chemical methods to control the BT, including toxicants, attractants, repellants, fumigants, and reproductive inhibitors. The eventual goal of this research is to implement their use in an integrated program to control the BT on Guam, prevent its dispersal from Guam, and control BT populations, when necessary, in other island situations. Control will be conducted by a variety of individuals and organizations, including WS, the Department of Defense, the Government of Guam, natural resource managers, military personnel, and others.

Development of Vertical Bait Stations for the BT—A horizontal bait station for killing BTs was developed in 1999 incorporating dead neonatal mice (DNM) treated with 80 mg of acetaminophen. These bait stations were made from footlong sections of polyvinyl chloride (PVC) pipe 4 inches in diameter. The stations were effective and convenient to rebait by hand, but some people were concerned that birds might get caught in them, too.

NWRC scientists decided to try similar bait stations hung vertically in hopes of minimizing the likelihood of bird capture. Using the fish crow in the laboratory studies as a surrogate for the endangered Mariana crow, NWRC researchers tested the ability of fish crows to remove DNM from stations made of pipes of different sizes. Footlong pipes of 2 and 4 inches in diameter were tested. Eighteen-inch-long pipes were tested at 4 inches in diameter



but not at 2 inches. Although the bait station made from 2-inch pipe at 18 inches long does exclude crows, there is some concern that smaller birds (e.g., endangered Micronesian starlings in the wild and Micronesian kingfishers, which are proposed for reintroduction) could take the BT bait and be killed.

BTs are not deterred from entering vertically positioned pipes, but NWRC scientists thought vertical positioning might discourage bird encroachment. So they tested bait stations 6 or 12 inches long at pipe diameters of 2, 3, and 4 inches. At all these vertically hung bait stations, BT bait-take was equivalent to that seen in the original studies using stations made from footlong sections of pipe 4 inches across, positioned horizontally. It is highly unlikely that a small bird could enter a vertical bait station made from footlong pipe 2 inches across. That size station will be evaluated with small birds before being used in WS operational activities against the BT on Guam.

Flotation Devices for Aerial Delivery of BT Baits—Operational management control methods to contain the BT on Guam include the use of live traps, hand-capture from fences at night using a spotlight, and searches of cargo with detector dogs. Live traps are also used to depopulate small forest plots. PVC plastic pipe bait stations containing DNM treated with 80 mg acetaminophen are also effective for reducing snake populations in small plots of accessible jungle forest on Guam. Bait stations are placed about 1.5 m above the ground in vegetation to reduce exposure to terrestrial scavengers (e.g., toads, crabs, monitor lizards, and feral pigs). Live traps or bait stations are not practical to use in remote, inaccessible, large-scale areas of forest, but aerial delivery of baits may be useful.

In some areas of Guam, baits that reach the ground would be taken by other species, such



as coconut crabs. Although acetaminophen is not toxic to the crabs, the baits are then not available for their intended target. Therefore, it would be advantageous to find a system to keep the baits in trees. Small plastic parachutes have been used for entangling treated DNM in forest canopy, but parachutes are relatively expensive and cumbersome to use. Inconvenience can be tolerated when only a small number are employed. But it is anticipated that several thousand DNM baits may be deployed at a time, and inconvenience must be kept to a minimum to maintain an efficient aerial drop.

NWRC researchers conducted evaluations on five types of flotation materials dropped by helicopter with DNM implanted with radio transmitters to record landing site (canopy or ground) and bait-take by snakes and nontarget animals. The types of material and percentage of baits that became entangled in the canopy were paper ring—39 percent, paper drinking cup—50 percent, excelsior (wood shavings) and burlap—56 percent, and commercial food cup—60 percent. For all devices, bait-take by snakes ranged from 19 to 50 percent, and bait-take by toads ranged from 0 to 11 percent. Although commercial food cups were the most convenient material to use because they could be nested together, even these cups made the bait-drops tedious. Collective experience over the past 2 years indicates that an efficient aerial delivery system will be difficult to achieve, so NWRC will conduct more development work.

Development of a Synthetic Bait Matrix for BT Control—For logistical and economic reasons, an artificial bait is needed to replace DNM that are used as the bait matrix for the snake toxicant, acetaminophen. NWRC has identified DNM skin bacteria as being critical in producing the decomposition odors that are attractive to snakes and elicit feeding behavior. A bioreactor synthetic matrix using bacteria from DNM skin may provide an attractive odor; a gel matrix using konjac has potential as the

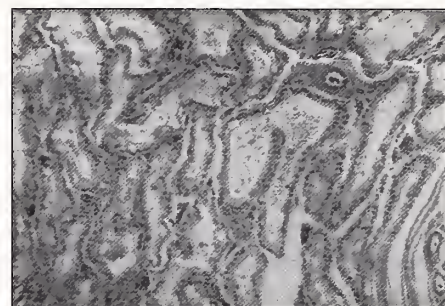
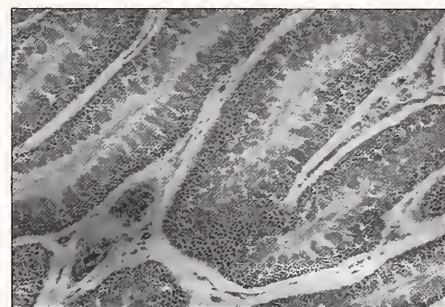
substrate for the bacteria. Konjac glucomannan is a water-soluble dietary fiber used as a thickener and stabilizer in food and pharmaceutical applications. On Guam, NWRC scientists conducted bait-take field evaluations among unadulterated DNM, konjac matrix treated with skin from DNM, and a konjac matrix inoculated with DNM bacteria.

Bait-take with the DNM was 93 percent and 30 percent with the konjac matrix treated with skin from DNM. None of the bacteria-inoculated konjac baits were taken.

These initial results are disappointing, but the investigators found that the konjac matrix did not have the correct formulation as evidenced by lack of bacterial growth, minimal odor of decomposition, and absence of flies and maggots on the matrix. A konjac matrix or other matrices with the appropriate nutrients to sustain bacterial growth will be developed before the next series of field studies is begun.

Reproductive Inhibition Methods for Controlling the BT on Guam—As part of a multiagency effort to develop methods for controlling the BT, NWRC research has been focusing on developing methods for inhibiting reproduction. Two methods have shown promise. One line of research is investigating immunization against endogenous GnRH—the hormone in vertebrates that mediates testes function in males and ovarian growth in females.

In an initial test using female BTs, all individuals vaccinated with an antigen conjugate consisting of c-GnRH-I (a form of GnRH found in snakes) and keyhole limpet hemocyanin (KLH) showed extremely high plasma titers of antibody against c-GnRH-I. Control snakes showed no antibody response. The next phase of work will investigate whether reproduction is effectively inhibited, and if so, the longevity of the effect.



The other line of research is investigating the effect of alkylating agents on BT reproductive function. In an initial test using males, a single 36-mg/kg oral dose of Thiotepea® (tris [1-aziridiny] phosphine sulfide) presented in a dead mouse bait, substantially disrupted spermatogenesis for at least 60 days. Spermatogonia, the germ cells giving rise to all other sperm cells, were largely destroyed in some test snakes, suggesting permanent sterility from Thiotepea in some cases.

The next phase of this work will investigate the longevity of the effect on adult males, the effect on testes maturation in juvenile males (i.e., possibility of permanent sterilization), and the effect of a single standardized dose level in males varying in body size. Work will also examine the effects of various alkylating agents, including Thiotepea, on ovarian growth in females.

PROGRAM SUPPORT

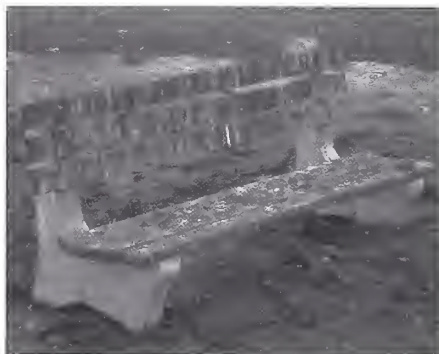
Registration Highlights

In conjunction with staff from the APHIS headquarters in Riverdale, MD, the NWRC Registration Unit is responsible for coordinating the development of data required for maintaining or modifying authorized uses of APHIS vertebrate control products to meet the varied demands involved in protecting agriculture, endangered species, and public health. To meet this responsibility, the Registration Unit works closely with scientists to ensure that research results will be acceptable for regulatory purposes and that study designs meet EPA and Food and Drug Administration (FDA) regulatory guidelines.

In 1988, EPA required all pesticides to undergo scientific review to determine reregistration eligibility. With the exception of zinc phosphide, NWRC and Riverdale headquarters staff successfully reregistered all APHIS vertebrate pesticide products. EPA is currently reviewing zinc phosphide, and all APHIS products are expected to be reregistered within the next 2 years.

In addition, the Registration Unit responds to requests from WS field personnel for new products or changes to existing products that will improve their ability to manage problem wildlife. Technical assistance and information are provided to State WS personnel, Federal and State agricultural and conservation agencies, as well as to other nongovernment individuals and groups.

APHIS vertebrate control agents are typically products that are not registered by private companies due to low demand but are important tools for managing wildlife problems. APHIS currently holds registrations for eight active ingredients used in vertebrate control



products. These active ingredients are formulated into 19 Federal registrations. Currently registered products meet the needs for bird management (five avicide products and one avian repellent), rodent management (seven rodenticide products and one fumigant), predator management for livestock protection (two predacides and one fumigant), and a toxicant for managing BTs on Guam (acetaminophen).

Pesticides

Bird Management Tools—Concern for human health and safety, agricultural damage, and threats to endangered species caused by birds continue to increase throughout the United States. Bird species that present the greatest problem include gulls (landfills and airports), starlings, blackbirds and pigeons (agricultural facilities and crops and urban areas), and corvids (agriculture, urban areas and conservation of threatened and endangered [T&E] species). A variety of tools has been developed to manage bird problems.

The NWRC Registration Unit has been instrumental in developing the only chemical repellent specifically designed for the protection of T&E birds from nest depredation. Mesurol® (methiocarb) is recognized as one

of the best avian repellants. Up until the 1980s, it was registered with EPA for many agricultural uses. Today, APHIS maintains a registration to use Mesurol as an aversive conditioning agent to train crows and ravens not to eat the eggs of threatened or endangered species. It is used by treating hard-boiled chicken or quail eggs and feeding them to ravens in nesting areas of T&E species prior to the beginning of their nesting season. Upon ingesting the egg, the corvid becomes ill and learns to avoid other eggs.

There is only one chemical registered for lethal control on birds, 3-chloro-p-toluidine HCl (Starlicide® or DRC-1339). APHIS holds the registration for five products containing DRC-1339. These tightly controlled products can be used to remove pigeons, gulls, starlings, blackbirds, and corvids from situations threatening human health and safety, livestock, agricultural crops, or T&E species. Through the selection of bait material, location of baiting sites, and timing, bird removal projects are highly refined to achieve maximum control utilizing minimal amounts of DRC-1339 and to reduce the impacts to nontarget organisms.

A major revision on the "Staging Area" DRC-1339 label was accepted by EPA during FY 2004. In cooperation with agricultural commodity groups, a study was conducted to support relaxing plant-back intervals when DRC-1339 is used in food or feed crops. With these data, EPA allowed shortening the 365-day plant-back interval on rice, wheat, corn, and barley to 15 days, and to 30 days on sunflower and soybeans. Relaxation of this restriction will greatly aid WS in directly targeting offending birds, thereby reducing the amount of bait placed in a field and subsequently reducing the nontarget impacts of a DRC-1339 baiting program.



During the last 3 years, the NWRC Registration Unit has received an increasing number of complaints concerning corvids. Current DRC-1339 labels do not adequately allow for controlling crow problems. To meet the demands of WS operational programs, plans are being made to register a sixth DRC-1339 label specifically for crows, ravens, and magpies.

Rodent Management Tools—WS has traditionally been involved in managing field rodents for agricultural protection. APHIS continues to maintain the registration of seven grain-based bait products (strychnine and zinc phosphide) as rodenticides and one incendiary cartridge for fumigating rodent burrows. The Registration Unit has been involved in a variety of product development projects.

The mountain beaver continues to cause problems with reforestation efforts in the Pacific Northwest. Working with a private rodenticide registrant and scientists from the NWRC Olympia, WA, field station, WS submitted to EPA an experimental-use permit request for permission to conduct a large-scale field-efficacy study. If approved by EPA, the field study will be conducted in the fall of 2004 and registration applications would be submitted to Oregon and Washington in 2005.

NWRC has coordinated and provided technical and administrative assistance to the Strychnine and Zinc Phosphide Consortia since 1988 and 1991, respectively. These consortia were established to help meet EPA reregistration requirements for these compounds. The registration eligibility decision for zinc phosphide was issued by EPA in 1998, and EPA is cur-

rently evaluating all of the data submitted in response to that document. All APHIS zinc phosphide products are expected to be reregistered by 2006. All reregistration requirements have been met for strychnine products. Consequently, the Strychnine Consortium was disbanded this year. APHIS' coordination of and participation in these two consortia saved the Federal Government hundreds of thousands of dollars in data development costs for the rodenticide products WS uses.

In cooperation with FWS, the NWRC Registration Unit is developing three rodenticide products that would allow the control or eradication of rodents on islands for conservation purposes. One diphacinone-based product would be registered only in the State of Hawaii but would allow for the control of invasive rodents in habitats critical to the survival of many species of endangered forest birds and plants. The Registration Unit conducted two environmental and two human-health risk assessments highlighting the low hazard presented by aerial baiting for rodent control. The other two products, one diphacinone and one



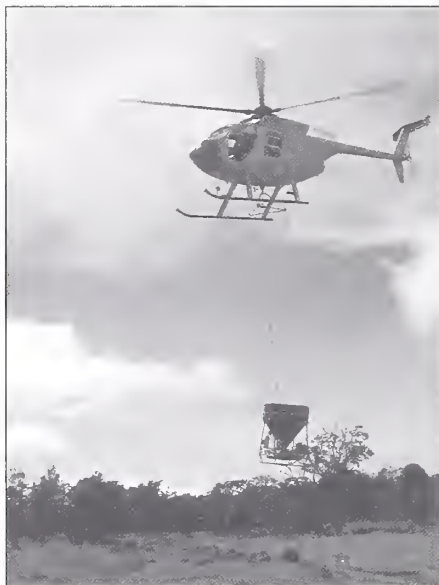
brodifacoum based, would be available for nationwide use and are specifically designed for the eradication of invasive rodents on islands.

These formulations will be a valuable tool for providing predator-free nesting habitat for hundreds of species of seabirds, especially in the tropical islands in the Pacific region and the Aleutian Islands of the Alaska Maritime National Wildlife Refuge. The registration applications for these products have been submitted to the Hawaii State Department of Agriculture and EPA for approval and should become available in as little as 1 year.

Livestock Predator Management

Tools—APHIS maintains the registration for four predicide products (technical and end-use products with Compound 1080 and sodium cyanide). The primary registration activity occurring with these products was the submission of a experimental-use permit request for sodium cyanide. This submission asked EPA for permission to conduct a study evaluating the effectiveness of using the M-44 to control canine predators for the protection of ground-nesting birds. The species of most concern is the sage grouse because populations are declining throughout the West. NWRC expects EPA to grant that permit in 2005, and WS will complete the study in 2008. An M-44 label amendment request should be submitted to EPA by 2009.

Snake Management Tools—Acetaminophen was approved for control of the BT on Guam and the Northern Mariana Islands in 2002. The Registration Unit continues to work with NWRC scientists to improve the efficiency of aerial baiting. Cost-effective aerial baiting techniques are essential to carry out snake



eradication efforts in critical conservation areas or in habitats where the use of bait stations is impractical.

In addition to development of aerially delivered toxicants, three natural, low-risk compounds—oils of cinnamon, clove and anise—have been made available for use as snake repellants. Fumigation techniques utilizing these oils were developed to drive snakes from cargo containers or other small areas. Formulations were also developed for use as hand-held snake repellants, similar to mace or pepper spray.

Wildlife Disease Research Disinfectant

—The NWRC BSL-3 infectious wildlife disease research facility will soon be available for research. To prepare for pending research activities, the NWRC Registration Unit helped secure a 3-year Emergency Use Permit from EPA to use paraformaldehyde for disinfecting animal testing rooms and equipment.

Wildlife Drugs and Vaccines

APHIS has five Investigational New Animal Drug (INAD) authorizations with FDA that allow interstate transport of the compounds for experimental purposes. Three of the compounds—GnRH, PZP, and Diazacou—are being tested as wildlife contraceptives.

APHIS has partnered with a private company to develop the PZP-based SpayVac™ immunocontraceptive vaccine (using an adjuvant developed at the NWRC) for white-tailed deer. APHIS is searching for a partner for the GnRH-based GonaCon Immunocontraceptive Vaccine. The other two compounds for which APHIS has INADs are alpha-chloralose and propiopromazine hydrochloride, both immobilizing agents. All of these products are for use by USDA personnel or persons under their direct supervision.

Immobilizing Drugs—Two immobilizing agents are under investigation by NWRC to humanely capture problem birds and mammals. Propiopromazine hydrochloride is used in the tranquilizer trap device for sedating animals captured in leghold traps. This compound significantly reduces the amount of potential damage the trap does to the leg of animal prior to being released. The immobilizing agent alpha-chloralose is authorized for use to live-capture waterfowl, coots, and ravens. In cooperation with the Wisconsin WS and a crane conservation group, APHIS submitted a special request to capture sandhill cranes with alpha-chloralose. As a followup to that project, NWRC assembled and submitted a data package to FDA requesting that FDA allow routine capture of cranes. FDA is expected to grant this request before spring of 2005. In addition to the crane use, APHIS obtained approval to use alpha-chloralose to capture mitred conure parrots in Hawaii and Gould's wild turkeys in New Mexico and Arizona.

Contraceptives—Scientists in NWRC's Product Development Program have successfully developed a hand-injected, single-shot immunocontraceptive vaccine based on GnRH that will render white-tailed deer and other mammal species sterile for multiple years. This product is now ready to begin the FDA approval process. NWRC's Registration Unit is responsible for the further development of GonaCon Immunocontraceptive Vaccine as a new animal drug. Once authorized by the FDA, this technology will be a valuable tool for deer management in areas where lethal control is not an option. GonaCon can then be used to treat other species by adding them to the label or through extra-label-use provisions.

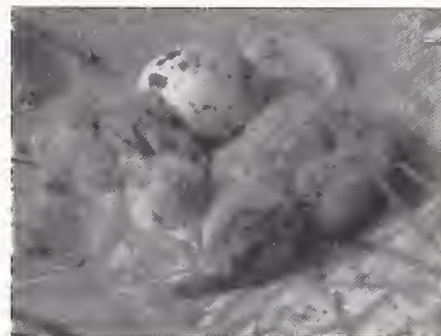
FDA requires a series of data submissions and toxicity studies to ensure the efficacy and safety of animal drugs. In cooperation with the APHIS Office of Policy and Program Development's Environmental Services branch, the Registration Unit has begun dialog with FDA on the development plan for GonaCon. Protocols are under development to test the storage stability and bioactivity of GonaCon, its toxicity to deer under multiple dose conditions, and its field efficacy.

A field study in cooperation with WS Maryland personnel began in July 2004 at the White Oak

Naval Surface Warfare Center and U.S. Army Adelphi Laboratory Center, both just outside Washington, DC. In this study, female white-tailed deer were administered GonaCon. Reproductive success (i.e., fawning rate) and general health of the vaccinated does will be monitored for 2 years to assess the effectiveness of GonaCon. With a strong product development partner or adequate program funding and positive test results, this product may obtain approval from FDA by 2009.

Regulatory Assistance Provided to Federal, State, and Nongovernmental Organizations

WS program personnel or other Government and nongovernmental cooperators often contact the NWRC Registration Unit for information when preparing Environmental Assessments, Environmental Impact Statements, and Section 7 consultations with the FWS. NWRC is the primary supplier of toxicity and other environmental effects data to the WS program and its cooperators. Often responses to these inquiries entail preparing unique summaries and interpretations of NWRC research. The NWRC Registration Unit cooperated with



WS National Environmental Protection Act staff on the development of two Environmental Assessments for field efficacy studies of two different contraceptive materials. These studies included a goose contraceptive study testing nicarbazin, a coccidiostat commonly used in the poultry industry, and GonaCon on white-tailed deer in Ohio.

NWRC personnel are providing technical assistance to a consortium of State, Federal, and nongovernmental organizations in Hawaii by developing a registration package and risk assessment for registering diphacinone as an aerially delivered anticoagulant rodenticide to control rats in conservation areas. In addition, biologists from the Alaska Maritime National Wildlife Refuge have enlisted help from NWRC in drafting a refuge wide management plan for eradicating rats and other nonnative rodents on scores of Aleutian Islands.

Information Transfer Activities

With the cooperation of headquarters staff, the Registration Unit continues to expand the NWRC Web site <<http://www.aphis.usda.gov/ws/nwrc/RegUnit.htm>> to include sample copies of the most current APHIS vertebrate pesticide labels as well as Wildlife Service's "Tech Notes," which provide information on the proper use of APHIS pesticide products.



WILDLIFE DISEASE RESEARCH PROGRAM

Increasing human populations means greater encroachment of people into wildlife habitats. That, in turn, leads to increased contact between wildlife and people and between wildlife and domestic animals. Elevated contact can escalate the potential invasiveness of new diseases threatening human, domestic animal, and wildlife health. Additionally, heightened worldwide mobility of people, animals, goods, services, and products can move new disease organisms and their hosts thousands of miles

in as little as a single day. Recent zoonotic diseases such as West Nile virus, wildlife rabies, hantavirus, and Lyme disease have resulted in a growing disease risk to humans, while other diseases such as scours in dairy cattle, bovine tuberculosis, brucellosis, avian influenza, and pseudorabies negatively impact livestock.

NWRC is conducting research to develop applied methods to mitigate and manage wildlife diseases (e.g., raccoon and skunk rabies,

bovine tuberculosis and West Nile virus) and identify bacteria found in urban geese and blackbirds associated with dairies and other pathogens that may cross from wildlife reservoirs to humans. Research is focused on development of surveillance and monitoring techniques, as well as effective, safe, and deliverable vaccines, barriers, and other methods to reduce or eliminate disease transmission.

Project Title: Avian Diseases: Carriage of Bacterial Pathogens by Canada Geese and Blackbirds

Goal: Understand the role that geese, blackbirds, house sparrows, and pigeons play as vectors and reservoirs for diseases affecting humans and domestic farm stock, and develop management recommendations that will minimize avian impact on human and animal health.

Disease transmission by free-ranging wild birds such as Canada geese, blackbirds, and pigeons is of increasing concern in the areas of public health and safety and agricultural production. Rapidly increasing populations of urban Canada geese are contaminating recreational areas with pathogenic bacteria that may pose human-health risks. Blackbirds and pigeons may also carry and disseminate emerging pathogenic bacteria that could affect livestock at confined animal feeding operation and dairies.

Transport of Cattle and Human Pathogens by Canada Geese—The growing populations of nonmigratory Canada geese have raised public health concerns in two areas: fecal contamination of public waterways



and lawns. There are many factors involved in calculating disease risk, including presence of pathogens in the environment, how humans or livestock may become exposed to the pathogens, and the susceptibility of the host to the pathogen. NWRC research is directed toward determining the nature of the pathogen population found in goose feces and the possible role geese may have in transporting pathogens across the landscape. The issue of calculating actual risk of acquiring disease in humans and livestock will be dealt with under future research studies.

In a recent study in southeastern Pennsylvania, Canada geese were radio-collared to determine their movement patterns across agriculture and urban landscapes. It was found that local populations of geese moved from rural pasture settings where they foraged in dairy and cattle pastures to urban parks, amusement parks, and lawns. *Escherichia coli* strains were found in the feces of geese and beef and dairy cattle as well as in grass and soil substrates, including seven strains of human or cattle-pathogenic *E. coli* in goose feces. Scientists were also able to determine that these strains contained genetic virulence markers for K1 (a trait to help the bacteria evade the immune system), *eae* (a trait that allows the pathogenic strain to attach to the intestine), and SLT-2 (a gene responsible for producing shiga-like toxins associated with hemorrhagic disease). These results suggest that geese may pick up pathogens from one site and transport them to another site and that goose feces contain pathogens of concern to human and cattle health.

Pigeons as Carriers of Dairy Cattle and Human Pathogens—Dairy cattle that are no longer productive generally enter the human food chain as the source of ground beef. If the cattle are infected with pathogenic bacteria at

the time of slaughter, fecal contamination of the beef is possible. A single infected cow can contaminate multiple beef products at the slaughterhouse level. One means of minimizing this risk is to increase biosecurity at the farm site.

In an effort to better understand sources of infection of cattle with human pathogens, biologists surveyed local pigeon populations at dairy farms in Colorado. Pigeons were identified as carriers of pathogenic *Salmonella* and *E. coli*. Eight percent of the pigeons carried some type of virulence marker gene associated with hemorrhagic disease in humans. Three percent of the pigeons carried pathogenic *Salmonella*.

Pigeons should be viewed as agents of transport or reservoir for human and cattle pathogens, and pigeon control should be incorporated as part of routine farm-side biosecurity measures.

NWRC Establishes Research Diagnostic Laboratory for Wildlife Diseases—

NWRC has set up a fully functioning BSL-2 research diagnostic laboratory to support its new wildlife disease research program. General methods supported include real-time polymerase chain reactions assays (RT-PCR). The laboratory is acquiring robotic capabilities for RT-PCR to handle large volumes of samples required for national-scale surveillance efforts. Other support includes a complete fluorescent imaging laboratory for histologic examination of specimens, enzyme-linked immunosorbent assays, cell tissue culture for virus isolation, plaque assay, and neutralization assays. The laboratory continues to develop and adapt assays to support disease surveillance research efforts. Initially, the activities have focused on diagnosis of West Nile virus and pox viruses.

Susceptibility of Greater Sage Grouse to West Nile Virus—

West Nile virus (WNV) entered the United States in 1999 and has spread across the country since that time. WNV is a vector-borne disease (primarily mosquitoes) that amplifies in birds. Humans and horses are dead-end hosts, which means they do not contribute to the ecological amplification and spread of the disease. Yet humans and horses are affected by it. About 20 percent of reported human cases give rise to serious neuroinvasive disease. There is approximately a 5-percent risk of mortality to humans. Horses have approximately a 40-percent risk of mortality, but recent vaccine developments have diminished this figure.

It is known that some bird species are highly susceptible to WNV. (For example, crows have about a 100-percent chance of dying if they become infected.) While not all birds die if they become infected, WNV is caused by an extremely virulent pathogen. There is concern how this pathogen might affect T&E species.

Recent field evidence from radio-collared greater sage grouse suggested that this soon-to-be listed species is highly susceptible to WNV infection. Researchers at NWRC carried out experimental infection tests on greater sage



grouse to determine their susceptibility to the disease and initiated pilot studies on new vaccines that might offer protection against the disease.

Prior to initiating the studies the investigators were required to house wild greater sage grouse in captivity for an extended period of time. This had never been accomplished. NWRC researchers were successful in keeping grouse for more than 7 months in captivity in the Center's flight pens. The success was even more remarkable in that the grouse showed lekking (reproductive) behavior in captivity and successfully bred. This has profound implications for conservation and captive-breeding efforts for this soon-to-be-listed species.

Unfortunately, the experimental infection studies confirmed that sage grouse are highly susceptible to infection, dying within 3 days of exposure to WNV. However, earlier vaccine trials suggest some protection against infection, offering the hope that small threatened sage-grouse populations might be captured and vaccinated against the disease.

Cliff Swallow Ecosystems as Predictive Surveillance Systems for WNV

Activity—Identifying the intensity of WNV activity for specific geographic areas is a high priority for vector-control managers and public health officials. Current surveillance systems have not achieved this level of precise predictive power. NWRC researchers have potentially identified a promising surveillance system in nesting cliff swallows with the identification of overwintering WNV-positive ectoparasites in swallow nests. This finding is significant because the virus may amplify early in the season in cliff swallow nests before it shows up in the general avian community.

It was also found that the prevalence of infection in nestling cliff swallows preceded disease identification in the nearby human population by about 5 weeks. Early identification of viral activity is important for public health and vector-control preparedness. The NWRC is currently providing the surveillance data to public health officials in Fort Collins as they develop and implement their vector-control strategies. The surveillance method has implications for the efficient management of this zoonotic disease.



Wild Mammals as Hosts for WNV—

NWRC scientists were contracted by the Centers for Disease Control to conduct a survey of small wild mammals and their exposure to WNV. Little information is available about effects of WNV on wildlife other than birds and whether there may be other virus-amplifying systems in addition to the classical mosquito–bird vector–host system. The first step in solving this question was to determine the range of mammalian species that might be exposed to infection.

Field surveillance in five States carried out by NWRC researchers and their WS operational counterparts indicated that raccoons, opossum, *Peromyscus* mice, and fox squirrels all are commonly exposed to WNV. Pending investigations under experimental laboratory settings will determine the extent to which these species are amplifying hosts.

Project Title: Controlling Wildlife Vectors of Bovine Tuberculosis and Rabies

Goal: To study the ecology of wildlife diseases, assess the risk of disease transmission among wildlife, domestic animals, and humans, and develop methods that reduce or eliminate such transmission.

One human–wildlife conflict that has received increasing attention is the potential transmission of diseases among wildlife, livestock, and humans. Throughout history, this type of disease transmission has produced devastating outcomes. Some of the more notable events were the plagues of the last 3,000 years, the influenza epidemic of the early 1900s, and the Great rinderpest pandemic of 1887–96. All of these events have been traced to close association of humans, or their livestock, with wildlife.

More recently, human–wildlife conflicts, resulting from actual or potential disease transmission, have become increasingly

important in the United States. Diseases such as WNV, hantavirus, and Lyme disease have resulted in zoonoses, while others such as pseudorabies and foot-and-mouth virus have the potential to negatively impact livestock.

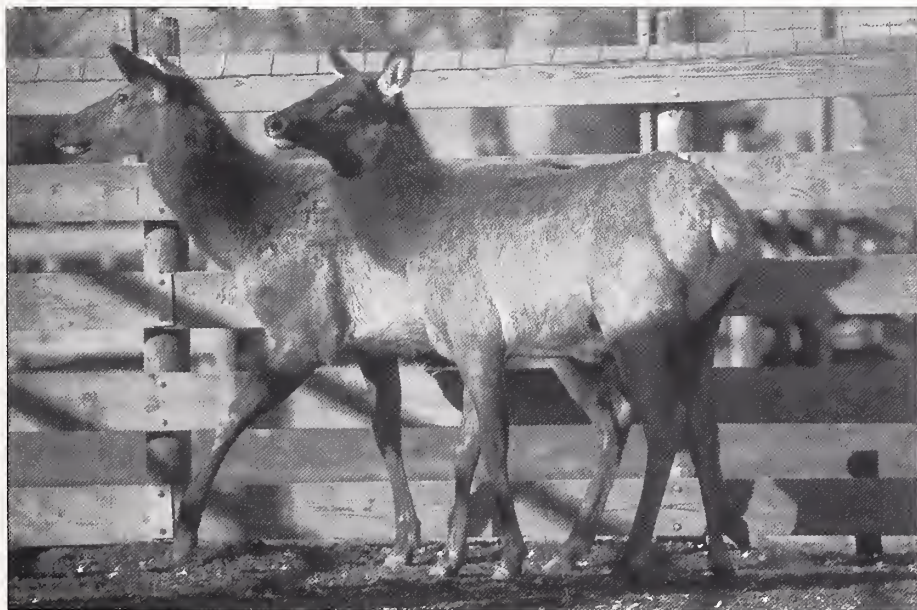
In 2000, the Secretary of Agriculture enacted Declarations of Emergency for bovine tuberculosis (TB) and rabies, citing threats to livestock and human health and safety. In an effort to eradicate TB and rabies, NWRC was directed to conduct research that would lead to a reduction or elimination of the potential transmission of these diseases between wildlife and livestock.

Use of Guard Dogs To Prevent Contact Between Cattle and Wildlife—

Bovine TB (caused by *Mycobacterium bovis*) is established in wild white-tailed deer in the northeastern portion of Michigan's Lower Peninsula. NWRC is developing and evaluating means to minimize direct and indirect contact between potentially infected deer and livestock. One research endeavor has involved livestock protection dogs.

Dogs have been used successfully for thousands of years to reduce predation on livestock, primarily sheep. NWRC researchers evaluated the ability of livestock protection dogs to minimize contact between wildlife and cattle within the TB-endemic area of Michigan on two privately owned deer farms. Both farms contained unnaturally high deer densities (240 deer/km² and 91 deer/km²), ensuring a challenging evaluation of the dogs. Protected pastures contained a dog and four calves; unprotected pastures contained just four calves. Investigators used four methods of data collection to establish how effective the dogs were: direct observations, motion-activated video, track plots, and trail monitors.

Through direct observations, it was documented that deer used cattle feed 113 times in unprotected pastures and never in a protected pasture and that deer came within 5 m of cattle 79 times in unprotected pastures but only 3 times in protected pastures. From video data,





it was shown that the dogs were effective in limiting deer use of cattle feed (protected = 2 deer visits, unprotected = 303 deer visits), limiting direct contact within 5 m (protected = 0 deer visits, unprotected = 114 deer visits), and limiting deer use of cattle pastures (protected = 3 deer visits, unprotected = 426 deer visits). Data from track plots and trail monitors also suggest that dogs may reduce the potential for disease transmission from deer to cattle.

Mesocarnivores' Activity in TB-Endemic Region of Michigan—White-tailed deer have been implicated as the primary species of wildlife responsible for continuously infecting cattle herds with bovine TB. Information on species that scavenge deer and are sympatric with deer and cattle, such as raccoon and red fox, could aid in understanding and managing TB. These mesocarnivores could also serve as effective sentinel species for assessing the presence and prevalence of TB in the environment.

Little is known about the ecology of raccoon or red fox in the TB-endemic region, though information on their home range sizes and dispersal distances is fundamental to determining if they could be effective sentinel species.

To address this issue, 56 raccoons and 5 red foxes have been radio-marked throughout a 4.63-km² farmland community in the TB-endemic area. Individuals are located three to five times per week via radio telemetry to ascertain home range, dispersal characteristics, spatial distribution, and proximity to livestock. To assess the potential for TB transmission from mesocarnivores to cattle, radio-marked individuals are further documented at cattle watering sites by data loggers and animal-activated cameras. Researchers are routinely documenting direct and indirect contact between mesocarnivores and cattle.

Oral Rabies Vaccination Program—

The primary means of controlling wildlife rabies in the United States has been through the use of oral rabies vaccinations (ORVs). Since the first field release of the *Vaccinia*-Rabies recombinant (V-RG) vaccine in 1990,

millions of vaccine-laden baits designed to target raccoons in the Eastern and Southeastern United States have been distributed.

Though the ORV program has been used successfully for nearly 15 years, a number of issues regarding its safety and efficacy have yet to be addressed. For example, better information is needed on vaccination rates in target populations, effects on nontarget populations, potential for vaccinated animals to shed *Vaccinia* virus, evaluation of biomarkers to evaluate vaccination rates, optimal barrier widths for vaccination, and more efficient delivery systems. NWRC scientists are addressing these issues by conducting field studies on raccoons and skunks and pen studies on a number of wildlife species.

Research by NWRC scientists has led to new bait designs, including bait-coated sachet packets, bait formulations to use with skunks, and better raccoon baits for delivery of the oral V-RG vaccine. Field studies are presently underway to evaluate these baits for skunks in five States. In collaboration with various universities, NWRC scientists are conducting research on raccoon and skunk ecology in urban as well as rural settings, on development of better techniques to estimate raccoon density, and on effects of density and target population distribution on vaccine bait distribution.

Although several studies have previously looked at the question of biosafety concerning the rabies vaccine being used in wildlife, some species were not evaluated. Therefore, pen-studies are underway at NWRC to address concerns of biosafety of the *Vaccinia* virus associated with rabies vaccine in selected avian and mammalian species. To date, tests have found no lesions or safety concerns due to the *Vaccinia* in several species of wildlife. The rabies vaccine V-RG appears to be safe for use in the field for wildlife.

Pseudorabies in Feral Hogs—NWRC researchers are determining the prevalence of diseases, primarily pseudorabies, in feral hogs in Texas and evaluating the potential for disease transmission from feral to domestic swine. GPS collars are being used to monitor the movements of feral hogs across the landscape and determine hog home range and movement patterns. During the initial effort,

30 feral hogs were captured and 8 adults were equipped with collars. Partial data results have been collected for some of the captured hogs, and pseudorabies and brucellosis infections have been documented.



Project Title: Evaluation and Management of Chronic Wasting Disease (CWD) Transmission

Goal: To assess the potential for CWD transmission at the interface between wild and domestic cervids and to develop methods to reduce transmission and spread.

CWD is a transmissible spongiform encephalopathy (TSE) of deer and elk. To date, this disease has been found only in cervids (members of the deer family). CWD is a nervous system disease and is typified by chronic weight loss leading to death. Species that have been affected with CWD include Rocky Mountain elk, mule deer, white-tailed deer, and black-tailed deer. Concerns over the spread of CWD among wild animals and its transmission to farm herds has increased as the disease has spread from northeastern Colorado and southeastern Wyoming to other States. NWRC

research is focused on examining the transmission of CWD between wild and domestic cervids and developing methods to reduce these interactions.

Interactions of Wild and Farmed Cervids Through Game Farm Fences—

Biologists are using track plots and motion-activated video to determine how commonly farmed and wild cervids (mule deer, white-tailed deer, and Rocky Mountain elk) interact through game-farm fences. The primary objective of the study is to determine if

disease transmission risk exists along game-farm fences. Nine fences around elk farms in Colorado and five fences around white-tailed deer farms in Michigan are being evaluated. Track-plot data are collected biweekly, and video data are collected continuously. Track plots document where animals visited the same point during a 24-hour period. Video documents when wild or farmed animals were at the fence and the nature of interactions.

Observations have found considerable variation in the species, sex, age class, and number of wild cervids that frequent game farm fencelines. Preliminary information indicates that direct interactions between farmed and wild white-tailed deer appear less common than between farmed and wild elk (1 versus 71 instances). Game-farm management practices such as stocking rates, proximity of males to females, feeding procedures, and fence construction all appear to contribute to the potential for interaction.

GIS is being used to document relationships between farmed and wild cervid interactions and the landscape. Based on these results, recommendations for methods of reducing interactions will be developed and made available to ranchers.



**Mule Deer and White-Tailed Deer
Telemetry Studies**

—In western Nebraska, where CWD occurs, NWRC is using telemetry to learn about the ranges and movements of mule and white-tailed deer. Concurrently, a fine-scale surveillance on the county level is being conducted to locate infected deer. Deer range in the area centers on the North Platte River, and the potential exists that CWD could move east along the river rather quickly if management actions are not taken. At the same time, NWRC researchers are continuing a long-term study of the ecology of deer along the Missouri River. Data from this study will be used in the development of movement models and formation of management decisions.





PROVIDING WILDLIFE SERVICES

Goal: Provide high-quality wildlife damage management services for our customers that result in the protection of agriculture, wildlife and other natural resources, property, and human health and safety.

NATIONAL SUPPORT

Indexing Feral Cat Activity in Florida—

An NWRC scientist worked with the WS Florida State Director and wildlife specialists from January to April 2004 to develop and implement efficient indexing methodologies to aid efforts to remove the feral cats that threaten the highly endangered Key Largo woodrat. For monitoring cats on Key Largo, sand plots were created atop the island's coral substrate along routes that cats were expected to follow. By collecting the data weekly to index cat activity, areas with high activity were targeted for live-trapping (cats were given over to a local animal shelter) and efficacy was assessed before mov-

ing traps to other areas identified by the index as needing trapping. In this way, feral cat populations in Key Largo woodrat habitat were efficiently and effectively reduced.

Raccoon Indexing Method Tested—

One of the primary nesting beaches for the threatened eastern spiny softshell turtle, on the Vermont shores of Lake Champlain, has suffered nearly 100-percent losses of nests to raccoon predation in recent years. An NWRC scientist from Fort Collins worked with Vermont WS to develop a raccoon indexing method for application to the Lake Champlain

beaches during the 2004 turtle nesting season. A photographic index based on trailmaster cameras was used in place of tracking plots.

Application of the method to assist control efforts is currently ongoing, with predation and benefit-cost ratios to be assessed at the end of the turtle nesting and hatching season. The data should permit analysis of efficacy of removal efforts and efficacy of an electric fence for excluding raccoons from the beach. It will simultaneously index other species, such as fox, that may also be preying on turtle nests.

Scientist Teaches Virological

Sampling—In June 2004, an NWRC scientist from Fort Collins traveled to Arcata, CA, to train researchers from the University of Minnesota and CSU in field methods for virological sampling of wildlife. It is anticipated that WNV could reach northern California this year. The training will assist these researchers in efforts to conduct WNV surveillance on northern spotted owls and their prey species. The owls are susceptible to WNV infection and are listed as threatened under the Endangered Species Act.

Assessment of Rodent Populations on

Lehua Islet—During the week of July 12–17, 2004, two NWRC scientists from the Hawaii field station conducted rodent surveys on Lehua Islet, Kauai. Lehua Islet, a State seabird sanctuary, is owned by the U.S. Coast



Guard and is located off the northern tip of Niihau, 17 miles west of Kauai. Its size is approximately 1 square kilometer.

NWRC scientists teamed up with five scientists from other State and Federal agencies as well as the National Tropical Botanical Gardens to assess rodent abundance prior to future eradication efforts. Rat activity was documented using tracking tunnels and snap traps; seven carcasses were collected for identification. Eradication of rats and rabbits will benefit restoration efforts for rare native plants on the island.

Evaluation of a Motion-Activated Laser Hazing System—In May 2004, NWRC scientists in Fort Collins completed their evaluation of a motion-activated laser hazing system for dispersing Canada geese in captivity. Relative to the pretreatment phase of the study, geese decreased their occupancy of

treated subplots by 83 percent during a 5-day habituation trial. When the habituation test was extended, goose occupancy decreased at least 92 percent during each of the 20 days of hazing. The efficacy of hazing was lost (i.e., extinguished) 3 days subsequent to the inactivation of the laser device. Thus, the motion-activated laser hazing system can be effective in dispersing Canada geese in captivity, but to be effective it must be in the activation mode.

Bird—Aircraft Strike Hazard Review—

On August 24–26, 2004, a researcher from the NWRC Sandusky, OH, field station was invited to Westover Air Reserve Base to participate in a review of the base's Bird—Aircraft Strike Hazard (BASH) plan. The scientist discussed NWRC's current research on grass management for airports, provided technical assistance on herbicides for brush removal and enhancement of native grasses, and reviewed changes in the

habitat management plans for the base. Members of the U.S. Air Force BASH team, representatives from the Massachusetts/Connecticut/Rhode Island WS program, and a Massachusetts State biologist also participated. During the meeting, minor revisions were made to the Westover BASH plan initiated after a 2001 meeting.

This compromise plan states that Westover will provide habitat for upland sandpipers and grasshopper sparrows while minimizing habitat attractive to wildlife near runways and taxiways. All grass within 300 to 500 feet of runways and taxiways will be mowed as needed to maintain height at 7 to 14 inches. Grassland habitat outside these zones will be mowed only once every year after completion of the nesting season (July 31). Bird numbers and strike rates will be monitored in upcoming years to determine the effectiveness of this mowing plan and make necessary adjustments.

INTERNATIONAL COOPERATION

Monkeypox Virus Investigation in Ghana, West Africa

—In March 2004, a scientist from NWRC and a small team of scientists and epidemiologists from the U.S. Centers for Disease Control and Prevention traveled to Accra, Ghana, to conduct an investigation of monkeypox virus. The 2003 outbreak of monkeypox virus in the United States is believed to have started following importation of exotic pet species from Ghana. The investigation involved three elements: evaluation of human disease, the search for animal reservoirs, and expansion of laboratory capacity to support incountry disease surveillance.

The team worked closely with personnel from the Noguchi Memorial Institute for Medical Research and the Accra National Zoo. Multiple biological samples were collected from animals sampled at two sites which were at or near the sites where the 2003 collections occurred. Animals with elevated levels of antibodies reactive with orthopoxvirus antigens were found at both sites.

Monitoring the Ethiopian Wolf—

The Ethiopian wolf is the rarest canid in the world, and monitoring its populations is essential to recovery efforts. An NWRC biometrician has developed a paradigm for indexing wildlife populations that provides indices with valid quantitative properties. One index method fitting into the paradigm is a highly successful passive tracking index (PTI) methodology that is now widely used within WS to monitor pest species and to index wildlife populations for disease control purposes. The PTI has been especially effective for indexing canids (members of the dog family), such as coyotes and foxes in the United States and dingoes in Australia. Because the PTI requires a minimum of resources, it is ideal for situations where resources are limited.

For that reason, scientists with the Murrelle Foundation collaborated in 2003 with the Center biometrician to test the PTI on African wildlife in the lower Omo Valley, Ethiopia, with success at monitoring hyenas, lesser kudu, dik dik, and baboons. Based on the success of this trial, tests were conducted in winter 2003–04 on using the PTI to monitor the Ethiopian wolf.

Jaguar Predation on Livestock—

An NWRC biologist from the Logan, UT, field station has traveled several times to Brazil since May 2000 to work with a Utah graduate student who is examining jaguar predation on native prey species and domestic livestock. Jaguars are an endangered species that have been causing serious depredation on cattle ranches in the Pantanal region. To date, eight jaguars and four cougars have been captured and radio-collared. GPS collars on 12 jaguars and 4 pumas have provided data on predation rates and sequences, prey species, age structure of depredated species, and movements. With approximately 2.5 years of data collection

completed using the GPS collars, more than 12,000 locations have been sampled and more than 400 kill sites have been identified. Scientists are now analyzing these data and preparing a final report for publication.

Spatial Ecology of Mongooses in the Caribbean National Forest, Puerto Rico

—Mongooses, an invasive species in Puerto Rico's Caribbean National Forest, are a major concern for two reasons. First, they are a potential predator on the Puerto Rican parrot, one of the world's rarest birds that is found only in the CNF. Second, there is a high prevalence of rabies in mongooses, with a number of attacks on humans in the CNF by rabid mongooses.

Knowledge of the spatial ecology of these animals is valuable information for developing management plans to protect the parrots and to distribute baits for the oral vaccination of mongooses against rabies. An NWRC biometrician collaborated with a California university



researcher and her graduate student in 2004 on a study whereby the student carried out research on the spatial ecology of mongooses using radio-collared animals. This study is among the first to describe mongoose spatial ecology in a rainforest habitat.

The study found that mongooses in the CNF lack spatial territorial structure and possess behavioral mechanisms that allow populations to reach very high densities. Removal by toxic baits or trapping may be a feasible management option for particular small-scale applications, such as reducing rabies transmission and attacks on people in picnic and other public use areas. Removal in the vicinity of parrot nesting trees would help protect fledglings that land on the ground. The majority of animals could be removed on these small scales in a short timeframe (less than a week).

For large-scale applications, eradication is unlikely, and rabies vaccination using oral baits would probably be the best option for reducing rabies transmission. The study also concluded that baits or traps could be more widely spaced in areas away from human-produced food sources. In addition, mongooses were found to use preferred travelways, and baits or traps should be more concentrated along those routes.

Tracking Stations for Detecting Mongoose on Kauai—In September 2004, two researchers from NWRC's Hawaii field station demonstrated use of an inexpensive and simple labor-saving technique to detect small invasive mammals on the island of Kauai. Kauai is the only major Hawaiian island where the mongoose was not intentionally introduced to control rats in sugarcane fields. Natural

resource managers are deeply concerned that if the mongoose becomes established on Kauai, it would be a serious threat to rare and endangered ground-nesting native birds, some of which exist only on that island.

The training session was for staff of the Kauai Invasive Species Committee and the State of Hawaii Department of Land and Natural Resources. The field employees were taught how to select census sites, set up field transects, position tracking stations, select appropriate baits, and identify target and non-target animal tracks and signs of visitations. Though there have been numerous public reports of sightings of the small Indian mongoose on Kauai, previous [conventional] trapping efforts have not been successful in verifying its presence.





VALUING AND INVESTING IN PEOPLE

Goal: Promote an organizational culture that values and invests in our people to support their professionalism, competency, and innovation as Federal leaders of wildlife management.

Wildlife Damage Management Working Group Officers

Drs. Kathleen Fagerstone and Ray Sterner are finishing 2-year terms as chair and secretary-treasurer of the Wildlife Damage Management Working Group of The Wildlife Society. During their tenure, the Working Group organized and held the 10th Damage Management Conference at Hot Springs, AR. The Working Group also held a symposium on wildlife diseases at the International Wildlife Society meeting in Christchurch, New Zealand, in December 2003 and held two symposia at The Wildlife Society meeting in Calgary, Canada, in September 2004.

Editor's Award—During the week of October, 12, 2003, Dr. Jimmy Taylor, a biologist from the NWRC Starkville, MS, field station, attended the 57th annual meeting of the Southeastern Association of Fish and Wildlife Agencies in Mobile, AL. He was recognized for his outstanding service as the associate editor for wildlife by the Southeastern Section of The Wildlife Society.

Society of Quality Assurance Chapter

President—NWRC Quality Assurance Officer Cathy Bens recently completed her term as president of the Rocky Mountain Chapter of the Society of Quality Assurance. Ms. Bens is also the newsletter editor for the chapter.

Library System Board President

Diana Dwyer, NWRC Information Specialist, recently completed a term as president of the High Plains Library Service System Governing

Board. High Plains Library System provides training and cooperative service support to libraries in northeastern Colorado. Ms. Dwyer is also the Special Library representative on the Colorado Library Consortium Board, a Statewide library system that supports Colorado libraries and their service to Colorado residents.

Equal Employment Opportunity (EEO)

Advisory Committee—Dr. Charlotte Miller chaired the WS EEO Advisory Committee during 2004 and also served in the same capacity for the Larimer County Federal Executive Association.

Educational Outreach—Several NWRC employees received recognition for their volunteer educational efforts in the Fort Collins public school system. Employees visited schools and made presentations on wildlife and how research is conducted.

Sabbatical Program—Analytical Chemistry Project Leader John Johnston participated in the NWRC Sabbatical Program in 2003–04.

Dr. Johnson's sabbatical allowed him to acquire new information for applying probabilistic risk assessment for the use of chemicals to better use chemistry based tools, such as vaccine and contraceptive baits, for improved wildlife damage. He also spent time collaborating with scientists at the Central Science Laboratory in the United Kingdom, attended workshops, and made presentations at an international conference in the Czech Republic.

2004 Publications Award

NWRC Director Richard Bruggers presented 2004 Publications Awards to the NWRC authors [in boldface type] of the following publications:

Blackwell, B. F.; Huszar, E.; **Linz, G. M.**; **Dolbeer, R. A.** 2003. Lethal control of red-winged blackbirds to manage damage to sunflower: an economic evaluation. *Journal of Wildlife Management* 67(4): 818–828.

Linz, G. M., ed. 2003. Management of North American blackbirds: proceedings of a special symposium of the Wildlife Society 9th annual conference; 27 September 2002; Bismarck, ND. Fort Collins, CO: U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center. 118 p.

These publications are excellent examples of the quality of research being done by Center scientists to address the complex issues surrounding wildlife damage management.



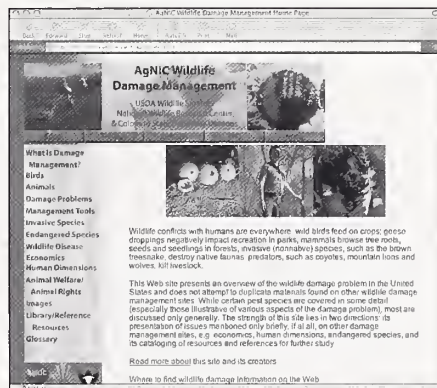
INFORMATION AND COMMUNICATION

Goal: Collect and analyze internal and external information to monitor and enhance program effectiveness. Communicate internally and externally to accomplish NWRC's mission and to build an understanding of the Federal role in wildlife damage management.

INFORMATION SERVICES

Information Transfer—The NWRC Web site has been updated and continues to expand. The NWRC symposium proceedings "Management of North American Blackbirds" is available full-text on the site, and all preliminary information for the NWRC-sponsored "Second National Invasive Rodent Summit" has been uploaded. New pages are available for the Wildlife Disease Program's CWD project and the surveillance, monitoring, and response project. The Wildlife Services "Research Needs Assessment 2001" is now accessible. A major restructuring of all project pages continues, and new guidelines and templates have been designed to standardize page design. All Bird Research Program pages have been reformatted, and Wildlife Disease Research Program pages are currently being updated. The NWRC 2003 Annual Publications List is complete and links to the full text of all 2003 publications. A history page on Charles Sperry has been added, and Information Services pages have been edited.

AgNIC Wildlife Damage Management Web Site—Information Services staff participated in a cooperative project with CSU Libraries' staff to produce a Web site for the Agriculture Network Information Center (AgNIC), a voluntary alliance of the National



Agricultural Library, land-grant universities, and other agricultural organizations, that, in cooperation with citizen groups and government agencies, focuses on providing agricultural information in electronic format over the Web. The AgNIC Wildlife Damage Management Web site is a valuable outreach tool for providing wildlife damage information to the general public. It is also regarded as a research tool for students wishing to pursue studies in this field.

New NWRC Video Released—A new video project entitled "The National Wildlife Research Center: Solving Animal Problems With Science" was produced and distributed. The video is 10 minutes in length and highlights NWRC research activities.

Wildlife Diseases Display—A new display on the Wildlife Diseases Program was designed and installed in the main hallway of the Wildlife Sciences Building.

Wildlife Services Image Database—Work continues on updating the image database and expanding its coverage. A new version of the Contentdm™ software allows users to download photos directly into PowerPoint to create slide presentations. The NWRC Information Specialist also gave a presentation on the database at the 22^d Vertebrate Pest Conference in March 2004.

Colorado Science Teachers Conference—More than 200 K–12 teachers attended the Colorado Science Convention held in Denver in November 2003. The NWRC Technical Information Specialist gave a presentation on the work done by NWRC and the educational materials created by WS. Thirty-five teachers attended the session and showed great interest in the material and how they could use the "Choices and Consequences" Internet modules and activity sheets in their classrooms.

Library—The library's new online catalog is now available to any user through the NWRC Web site. The catalog provides access to both library materials and NWRC unpublished

reports located in the archives. Additionally, new catalog entries for NWRC-authored papers contain direct hypertext links to the full-text articles. Staff has also begun adding journal names and holdings to the catalog and is preparing for implementation of an automated circulation system.

Information Services Unit staff borrowed or photocopied almost 1,600 items from other libraries in response to information requests from the WS program and lent 200 items in return. Additionally, staff photocopied nearly 5,000 inhouse journal articles, reports, and NWRC-authored reprints for distribution to researchers and WS Operations staff. More than 8,700 other NWRC or WS information products were distributed, including children's activity sheets and information packets. Almost 150 new items were added to the NWRC catalog, including dissertations, theses, reports, proceedings, and reference items. Overall reference information requests totaled nearly 400, with almost a third of the requests arriving via e-mail from the NWRC Web site.

A shelf inventory, begun in FY 2003, was completed. Records for all missing books were removed from the catalog, new records were added, and incomplete or erroneous records were edited. In all, more than 500 records were updated. Duplicate and outdated materials were removed from shelves, and more than 50 boxes of journal back issues were packed and moved to the warehouse to clear shelf space in the library.

A new library brochure is now available for handout. The brochure details library services and provides staff contact information. Three versions of the brochure are available so dissemination of library information can be customized for various user groups. The library also has purchased a multiple-user version of Reference Manager™, a personal bibliographic software package, and will begin

converting ProCite databases to work with this new software. Library staff will soon begin customizing a new software and interface for interlibrary loans.

Archives—The mission of the NWRC Archives/Records Management Unit is to collect, preserve and make available the research records and materials that document the history of NWRC. To that end, much of the Archives' work focuses on tasks to organize and make accessible historical records. The Archives also highlights, in exhibits and staff outreach activities, materials that tell the story of NWRC's work throughout the years.

The third annual NWRC Archives Week was held October 27–31, 2003. The highlight was a presentation by Thomas Canby, retired National Geographic Society writer, who talked about his 1977 article "The Rat: Lapdog of the Devil." The Center was prominently featured in this article and Tom, with slides, recalled his travels and reminisced about Center personnel. In addition, an open house on October 29 highlighted interesting records from the archives. All displays focused on Center rat

research. In the lunchroom, a display of personal artifacts from two retiree heads of former field stations highlighted the Philippine Field Station bulletin board. Archives Week is held to highlight the NWRC archives and provide staff an opportunity to view interesting historical records.

Exhibits—In January 2004, a new display was installed in the NWRC hallway exhibit case. "Sharing the Air: NWRC Bird Strike Hazard Research" featured the history of NWRC's work on bird strike hazards. From the early 1950s to the present, NWRC has worked on the conflicts between birds and airplanes. In addition to the exhibit case, the display included an interactive computer program and a container of live fescue grass, which is not as attractive to birds as other types of grasses often found on airports.

General Archival and Records Management Work—The Records Management and Archives staff finished a 2-year project in August 2004 regarding unpublished material that was transferred to the National Archives and Records Administration (NARA)



in the late 1970s. Through a Memorandum of Understanding, NWRC regularly received the records, provided holdings maintenance, and updated the NWRC online catalog to better organize the material. The records were moved from 31 cardboard boxes to 113 archival-size boxes. The project was vital to the accessibility of the material. The NARA records are NWRC's historical memory, so preserving them was extremely important.

In April 2004, the Records Manager/Archivist and the Director's Office secretary completed a 1-year project to reorganize the Director's Office records in the archives. The goal of the project was to eliminate duplicates, comply with the APHIS Records Management Manual records schedule, and discard records other than permanent or historical material. All records are now organized in archival boxes and will eventually be entered into a database, making them much more accessible.

SEMINARS

The NWRC seminar program offers a valuable forum for the exchange of ideas among Center staff, field station personnel, visiting scientists, and WS staff. During 2004, NWRC hosted 20 seminars, including presentations by speakers from various universities and foreign wildlife organizations, NWRC headquarters and field station staff, and potential candidates for employment. Topics included river otter research, wildlife disease in the United Kingdom, jaguar research in Brazil, pelican and cormorant management, black-footed ferret recovery, and feral pig damage in Australia.



NWRC Seminars

Speaker	Affiliation	Topic
Nathan Roberts	University of Missouri	Missouri's river otter experience
Tommy King	NWRC Mississippi Field Station	Overview of American white pelican impacts on southeastern aquaculture
Pete Robertson	Central Science Laboratory, York, U.K.	Wildlife TB in the U.K. and other stories
Gary Littauer	USDA-APHIS-NEPA	NEPA and Wildlife Services—working in the gray area
Catherine Bens and Laura Greiner	NWRC, Fort Collins	Archiving refresher: questions, answers, and tour of the archives
Brian Washburn	NWRC, Sandusky, OH	Geese, gulls, guns, and grass: Research for reducing aviation-wildlife conflicts
Steven Lapidge	Pest Animal Control Cooperative Research Center, Canberra, Australia	Feral pigs in Australia—damage, control and research
Giovanna Massei Smith	Central Science Laboratory, York, U.K.	Conditioned taste aversion: a U.K. perspective
Greg Phillips	NWRC, Fort Collins	Effects of disturbance on elk reproductive success
Eric Gese	NWRC, Logan, UT	Interactions between jaguars and livestock in the southern Pantanal, Brazil
Arla Hile	NWRC, Philadelphia, PA	New perspectives in the development and application of repellants
John Russell	British Columbia Ministry of Forests, Forest Genetics Section	Genetic variation in deer browse and terpenes in western redcedar: is resistance breeding a possibility?

NWRC Seminars (continued)

Speaker	Affiliation	Topic
Tyler Campbell	Warnell School of Forest Resources, University of Georgia	Managing matrilineal social groups: a viable alternative for deer?
Roger Applegate	Kansas Department of Wildlife and Parks	What we know about the bobwhite in Kansas: highlights from recent research
Donald E. MacLauchlan	International Resource Director, International Association of Fish and Wildlife Agencies, Washington, DC	The role of the International Association of Fish and Wildlife Agencies in wildlife management
Mike Lockhart and Pete Gober	FWS, Laramie, WY	Background and current obstacles to black-footed ferret recovery
John Johnston	NWRC, Fort Collins	Development of chemistry-based tools for wildlife management
Graham Smith	Central Science Laboratory, York, U.K.	Modeling rabies control in wildlife
Frank Hansen	University of Pennsylvania	Spatial models of the fox tapeworm and their use for developing management strategies
Pete Robertson	Central Science Laboratory, York, U.K.	Wildlife and bovine tuberculosis in the United Kingdom

MEETINGS, WORKSHOPS, AND CONFERENCE PRESENTATIONS

Joint Rabies GIS Planning Meeting—

On May 25, 2004, NWRC scientists participated in a joint planning session with the WS rabies coordinator and rabies GIS specialist. Since 1922, there have been more than 10,000 positive cases of skunk-variant rabies in California, with over 1,200 cases in livestock and 20,000 in pets. GIS plots revealed three traditional "hot spots" of skunk-variant rabies in the State (i.e., Contra Costa–Alameda, San Luis Obispo–Santa Barbara, and Butte–Yuba–Sutter counties). Strategies were devised to estimate disease impacts and ORV costs. Ultimately, scenario and forecast analyses will be provided as decisionmaking tools for evaluating the potential savings likely to accrue from a skunk-variant rabies ORV program.

Caribbean Tree Frog Presentation—

Two researchers from the NWRC Hawaii field station made a presentation at the Pepeekeo Community Association meeting on the Big Island on June 19, 2004. Approximately 14 people attended the meeting, including realtors and landowners of a new 100-lot subdivision. The presentation consisted of ecological, prevention, and control information on invasive Caribbean tree frogs, and information on other invasive-animal research conducted by the NWRC field station. The researchers discussed preventing frogs from entering an area by inspecting all plants and landscaping materials, properly disposing of yard debris and clearing understory vegetation, and not collecting plant material from transfer stations or infested areas. The researchers plan to keep in contact with association members to answer additional questions.

Hawaii Conservation Conference—

Scientists from NWRC's Hawaii field station attended the Hawaii Conservation Conference June 29–30, 2004. The scientists presented NWRC research on the development of new mongoose lures, attractants, and baits, coqui frog hydration effects on pesticide efficacy, and a poster on partnerships among research, management, and community associations in coqui frog control. The poster presentation was developed in conjunction with the Hawaii operational program. More than 500 people from around the world attended the conference.

North Dakota Blackbird Research Pre-

sentation—On July 6, 2004, a scientist from the NWRC Bismarck, ND, field station and researchers from North Dakota State University (NDSU) met with members of the FWS Habitat and Population Evaluation Team in Bismarck to discuss research of mutual interest. An NDSU doctoral student presented a seminar on the effects of landscape features on blackbird populations. A critical aspect of this research is discovering if there is a predictable link between annual precipitation, wetland numbers, and blackbird populations. This would be valuable information for predicting areas of the sunflower growing areas likely to have significant blackbird damage. The meeting participants have agreed to explore conducting collaborative studies that would benefit all wetland dependent birds.

International Society of Chemical Ecology Meeting—

The NWRC sponsored a symposium at the International Society of Chemical Ecology annual meeting held July 25–28, 2004 in Ottawa, Ontario. The topic of the symposium was "Chemically Mediated Behavior in Wildlife: Examination and Application." Two NWRC scientists from Fort Collins and Olympia co-organized the symposium and presented papers on applying knowledge of chemically mediated behavior to protect forest resources from damage by herbivores.

Hawaiian Bat Research Cooperative

Meeting—On July 26, 2004, a researcher from the NWRC Hawaii field station participated in a meeting of the Hawaiian Bat Research Cooperative. Approximately 25 county, State, and Federal agency personnel, administrators, researchers, educators, private land managers, and individuals make up the cooperative, whose main interest is the preservation of the endangered Hawaiian hoary bat. The cooperative recently received a \$375,000 grant to study habitat use and distributional patterns of the nocturnal mammal, as well as the potential impact that harvesting of eucalyptus and other forest tree species may have on the bat. Hawaii WS research and operational units have previously consulted with FWS about reducing impacts to nontarget native species, including the hoary bat, during coqui frog control operations.

XIXth International Congress of

Zoology—On August 23–27, 2004, two NWRC scientists participated in the XIXth International Congress of Zoology held in Beijing, China. More than 650 people from 46 countries attended the conference, which had more than 50 symposia covering a wide spectrum of zoological topics including evolution, systematics, ecology, conservation, biology, reproductive biology, diseases, ethics, and philosophy. The NWRC scientists presented papers in the Rodent Ecology Symposium including an overview of rodent ecology and plague, and current information on mountain beaver biology. Additionally, the scientists were able to exchange information with leading scientists from around the world and discuss emerging and ongoing concerns relative to rodents.

In conjunction with the meeting in Beijing, the NWRC scientists met with other members of the organizing committee for the Third International Conference on Rodent Biology and Management, making preliminary plans for the next meeting to be held in Hanoi, Vietnam, during 2006. An individual tour of the Institute of Zoology, Chinese Academy of Sciences, was arranged for the NWRC scientists by its Director, Dr. Zhibin Zhang. Dr. Zhang has collaborated with NWRC on several projects and took a sabbatical with the NWRC Olympia, WA, field station during 1996.

CSU Student Visit—On August 17, 2004, an NWRC scientist in Fort Collins provided an overview of WS operations and research activities to a group from CSU. The 18 graduate students are part of a master's degree program that prepares them for careers in farm management. Students in this program are educated in farm practices, finance and policy, as well as wildlife, range, and water resources management. The students were shown the research facilities at NWRC and several expressed interest in doing internships with NWRC.

16th International Sunflower

Conference—On August 30–September 1, 2004, a scientist from the NWRC Bismarck, ND, field station attended the 16th International Sunflower Conference in Fargo, ND. The meeting, which is held every 4 years in a sunflower-growing area of the world, was attended by 280 scientists representing 25 countries. The NWRC researcher and collaborators from NDSU presented six posters and papers with topics ranging from geospatial analysis to quantify wetland habitat used by roosting blackbirds to use of wildlife conservation plantings to attract blackbirds away from commercial sunflower fields.

Joint Meeting of the Bird Strike Committee–USA and Bird Strike

Committee Canada—On September 13–16, 2004, almost 400 people and 21 exhibitors from 25 countries attended the 6th annual joint meeting of Bird Strike Committee–USA and Bird Strike Committee–Canada in Baltimore, MD. Additionally, 44 FAA

Airport Certification Inspectors attended the Wednesday morning session. In all, 55 technical papers and posters were presented, including 22 by WS biologists. Scientists from the NWRC's Sandusky and Philadelphia field stations and NWRC headquarters in Fort Collins presented talks. The goal of the bird strike committee is to increase communication and professionalism among the diverse groups dealing with wildlife issues on airports. WS biologists are playing an increasingly important role in reducing wildlife hazards at U.S. airports as exemplified by assistance provided at 565 airports in 2003. The next USA–Canada bird strike meeting will be held August 15–18, 2005, in Vancouver, BC.

Scientist Presents BT Research—

On September 20, 2004, an NWRC scientist from Fort Collins presented a summary of BT field research at the WS office on Guam. Participants at the meeting included personnel from the Guam National Wildlife Refuge, FWS, the Guam Department of Agriculture, the U.S. Geological Survey, and WS. Topics discussed included evaluations of aerial bait delivery systems, bait matrices as alternatives to the dead mouse for delivering acetaminophen-treated baits to snakes, and methods used for determining a population index for hermit and coconut crabs.

PUBLICATIONS

[**Boldface** type indicates an NWRC author.]

Akenson, J. J.; Nowak, M. C.; Henjum, M. G.; **Witmer, G. W.** 2003. Characteristics of mountain lion bed, cache and kill sites in northeastern Oregon. In: Becker, S. A., et al., eds. Proceedings of the 7th mountain lion workshop; 15–17 May 2003; Jackson, WY. Lander, WY: Wyoming Game and Fish Department: 111–118.

Arjo, W. M. 2003. From seedlings to crowns: these species cover it all. *Western Forester* 48(4): 15.

Arjo, W. M. 2003. Is it a pocket gopher or mole? *Western Forester* 48(4): 12–13.

Arjo, W. M. 2003. Mountain beaver: the little rodent with a large appetite. *Western Forester* 48(4): 10–11.

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